# Metallurgist

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# METALLURGIST

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# METALLURGIST

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# IVAN PAVLOVICH BARDIN

Translated from Metallurg, No. 1, pp. I-III, January, 1960

Soviet metallurgy has had a severe loss. On January 7, while performing his official duties, the eminent metallurgist, Hero of Socialist Labor and Vice-President of the Academy of Sciences of the USSR, Academician Ivan Pavlovich Bardin died.

He was born November 13, 1883, in the village of Shirokii Ustup in the Saratov province, of a peasant family. He received his primary and secondary education in trade and agricultural schools. After completing the courses of the agricultural school in 1902, at the insistence of his parents, who had hopes that he would become an agriculturist or land surveyor, Bardin entered the Novo-Aleksandriiskii Institute of Agricultural Forestry, from which he was expelled for political unreliability.

In 1906 he entered the Kiev Polytechnical Institute, at first in the agricultural and then in the chemical department, from which he was graduated in 1910, having specialized in the metallurgy of cast iron and steel under Professor V. P. Izhevskii who inculcated in him a deep interest in ferrous metallurgy.

After graduation from the Institute, Bardin for a time managed a test of an electrical furnace system of Professor Izhevskii at the Bryansk factory, and then worked temporarily at the All-Russian Exposition at Ekaterinoslav. The efforts of the young engineer to get work in his specialty in tsarist Russia were unsuccessful. In October, 1910, he was obliged to go to the USA, where he worked for more than a year as a laborer in the rolling-mills at Gary. Bardin's health, however, did not hold up under heavy work. In 1911 he returned to his native country and in 1912 went to work at the Yug factory, where he met a remarkable Russian blast-

furnace worker, M. K. Kurako. This encounter had a considerable influence on Bardin's life.

Later on Bardin worked in the Enakievo factory. After the departure of Kurako to Siberia in 1915, Bardin was named manager of the blast-furnace plant, and the chief engineer of the factory.

Bardin greeted the Great October Revolution with joy. He continued to work as the chief engineer of the factory. The working conditions were difficult. Hardly any ore and coal arrived at the factory. During the time of the civil war and disorder, when the entire metallurgical industry of the South was idle, only one blast furnace of the Enakievo factory worked, and it was operated by Bardin. From the very first days of Soviet power Bardin resolutely stood on the side of the conquering proletariat, and, from that time on, his life, all his knowledge and productive experience were devoted to socialist building, to the growth of the ferrous metallurgy of the Soviet Union.

During the years of restoration of the national economy he was chief engineer at the large-scale metallurgical factories of the South, at Enakievo, Makeevka, and the Dzerzhinskii; he directed their reestablishment and restoration. He was a tireless fighter for advanced techniques. His participation in the development of projects in the reconstruction of the southern metallurgical factories is a model of struggle against routine , against people who were afraid of the new. Thus, contrary to the opinion of some metallurgical specialists, expressed in opposition to the construction of 100-ton open-hearth furnaces, the first 100-ton furnace in the Soviet Union was converted from a 50-ton furnace in 1927 at Dzerzhinskii factory by Bardin. Many blast furnaces were mechanized under his supervision.

In 1929 the government appointed Bardin technical director of construction of one of the first giants of Soviet metallurgy, the Kuznetsk metallurgical combine. The combine was put in operation in 1932. It had been built in 1000 days. Here enormous credit goes to Bardin, who knew how to mobilize people in overcoming the difficulties connected with construction. Bardin worked eight years at the post of technical director of the Kuznetsk metallurgical combine. After that period the construction of the combine was completed and it became the leading metallurgical enterprise of the country.

In 1937 Bardin was named chief engineer of the Central Administration of the Metallurgical Industry of the National Committee on Heavy Industry; he then occupied a series of managerial posts: chairman of the technical council of the National Committee on Heavy Industry, deputy national commissioner of ferrous metallurgy, etc.

In 1932, the general meeting of the Academy of Sciences of the USSR elected I. P. Bardin an active member of the Academy. He directed the A. A. Baikov Institute of Metallurgy, which he founded, and organized the Ural affiliate of the Academy, where he worked as president until his death.

Bardin was an initiator and active participant in the founding of the Central Scientific Research Institute, for which he worked as a director from the moment of organization of the institute in 1944 until his death.

In 1942, Academician Bardin was elected vice-president of the Academy of Sciences of the USSR. From the first days of World War II he worked as deputy chairman of the Academy commission on mobilization of the resources of the eastern regions for the needs of defense. For the work completed by this commission upon the solution of basic problems in the economic development of the Urals during the war, Bardin , along with other members, was awarded a first-class Stalin Prize in 1942.

By order of the Presidium of the Supreme Council of the USSR, on June 10, 1945, Bardin was awarded the title of Hero of Socialist Labor for outstanding service in the work of the planning, construction, and mastering, of large-scale metallurgical factories, and for scientific achievements in the field of ferrous metallurgy.

After the war, Bardin participated directly in developing long-range plans for the development of ferrous metallurgy. He displayed a great deal of creative initiative in the solution of complicated problems relating to the introduction of new technique. He did much work on intensification of the metallurgical processes, on the creation of new, more improved designs of metallurgical aggregates, on the assimilation and complex utilization of new forms of metallurgical raw materials. In 1949, Bardin, along with a group of workers in the "Hammer and Sickle" factory, was awarded a first-class Stalin Prize for work on the intensification of the open-hearth furnace process with oxygen.

Research done under the direction of Bardin was directed toward further increase in the capacity and productivity of blast furnaces, the improvement of methods of preparing raw materials, the betterment of the design of open-hearth furnaces and the increased utilization of heat in them. Bardin organized the investigations connected with the introduction into factory practice of continuous casting of steel. In April, 1958, with a group of factory workers, he was awarded the Lenin Prize for the creation of the first industrial installations of continuous steel casting.

He was one of the learned who unite in themselves an analytical mind with creative energy and outstanding engineering and organizational talent.

There is no technical problem or problem of the national economy in the area of ferrous metallurgy in the solution of which Bardin did not participate. Various problems were worked out by him and by those under his direction: the complex utilization of iron ores, the improvement of industrial utilization of poor iron

ores, the production of blast-furnace ferroalloys in a blast enriched with oxygen, the use of oxygen for intensification of metallurgical processes, the improvement of steel-pouring processes, the utilization of titanium-magnetite ores, etc.

Bardin was director and participant in work on the formation of the titanium industry of the Soviet Union, the production and introduction of heat-stable alloys, which are the foundations of our new technique.

An invaluable role was played by Bardin in the development of regions remote from the center. He was a tireless investigator of regional problems and problems connected with the complexes, and also of problems of the geographic disposition of industry. He wanted to see everything personally. The itineraries of his trips in the USSR and around its borders were complete and extensive. Bardin visited all the corners of our country in which there are metallurgical factories, possible raw material or fuel resources. In recent years he was the director and organizer of a series of meetings and conferences on the study of the productive forces of the eastern regions of our country.

In 1958, Bardin headed and conducted a conference in Irkutsk on the study of the productive forces of Eastern Siberia. He personally travelled the most distant corners of Siberia, was in Yakutiya, in Magadan, and other cities.

During the last two months of his life, Bardin visited once again Kuzbass and the Urals, where he directed an affiliate of the Academy of Sciences. Quite recently he was in Krivoi Rog, where the best iron-ore deposits of our country are concentrated.

Bardin did enormous work in the organization and accomplishment of scientific investigations according to the program of the International Geophysical Year.

The services performed by Bardin have been highly valued by the Soviet government. He was awarded seven Orders of Lenin and medals. In 1959 the Swedish Academy of Sciences awarded him the Brinel gold medal.

Bardin combined scientific work with great governmental activity in various organizations. He was a deputy at four sessions of the Supreme Council of the USSR, and a permanent member of the council of experts of the State Planning Committee of the USSR.

The name of Ivan Pavlovich Bardin is widely known, not only in the USSR, but abroad. He was an active member of the Rumanian, Czechoslovak, Hungarian, and German Academies of Sciences, the English Iron and Steel Institute, the American Geographic and Railroad Societies. He was awarded orders and medals of foreign countries many times.

He died January 7, 1960, at a session of the Commission for development of a long-range plan for the growth of ferrous metallurgy, where he spoke on problems dealing with iron ore.

This death is a grievous loss to the Soviet nation, Soviet science, ferrous metallurgy, and our entire industry.

The image of Bardin, a great scholar, engineer and patriot, will remain forever in the hearts of the Soviet people.

# THE TASKS OF THE USSR FERROUS METALLURGY IN 1960

Translated from Metallurg, No. 1, pp. 1-3, January, 1960

The Soviet Union, on the basis of very profound reorganizations in all areas of its economic and sociopolitical life, has entered a new and most important period of its development, the period of extensive building of a communist society. The preliminary figures for the development of the national economy of the USSR adopted by the Twenty-first Congress of the Communist Party of the Soviet Union constitute the first step of our road to the creation of the material and technical basis of communism.

The Soviet nation has greeted the historic decision of the Congress with enthusiasm and is fulfilling the tasks of the Seven-year Plan. In 1959, the rates of growth of production of industrial products exceeded the average annual task of the Plan; the yearly quota was overfulfilled by about 4%.

Metallurgists of the USSR successfully fulfilled the annual plan. Our blast-furnace workers, rolling-mill operators and steel-furnace workers produced hundreds of thousands of tons of cast iron, steel and rolled iron, and our miners, about 1.5 million tons of iron ore.

In 1959, in this country, 43 million tons of cast iron and 60 million tons of steel were smelted, 47 million tons of rolled iron were produced and 94.3 million tons of iron ore were mined. The smelting of cast iron and steel in the USSR in 1959 amounted to more than in England, France, and West Germany combined, and in iron-ore mining the USSR in 1958 and 1959 occupied the first place in the world.

The builders of steel works also considerably improved their work. In 1959, the volume of capital investments in them amounted to about 10.5 billion rubles, that is 25% more than in 1958.

During the year large-volume blast furnaces were put in operation at the Nizhne-Tagil'sk combine and at the "Azovstal'" factory, as were powerful open-hearth mills, and seven new rolling-mills were constructed at the Magnitogorsk Metallurgical Combine, a blooming and sheet mill at the Cherepovetsk factory and a large-scale mill at the Nizhne-Tagil'sk combine. A large-scale curved profile works was put in the "Zaporozhstal'" factory. Heavy-duty equipment for mining iron ore was started, including the very large scale Novo-Krivorozhe ore-enrichment combine which was put in operation ahead of schedule.

The builders of metallurgical factories did not completely cope with their tasks, however, and part of the aggregates will go into operation in 1960, not in 1959.

In spite of the successes obtained in the development of ferrous metallurgy, the needs of the national economy in 1959 in ferrous metals were satisfied with great effort. There were special difficulties in supplying the national economy with pipe and some types of rolled iron, and also in mining iron ore.

Next year, 1960, is the second year of the seven-year period, and to a great extent the fulfillment and over-fulfillment of the tasks of the entire Seven-year Plan will depend on fulfilling the plan for this year.

Measures undertaken by the enterprises of ferrous metallurgy in the course of fulfilling the 1959 plan, and the broadly expanded movement for completion of the Seven-year Plan ahead of time, have enabled us to discover new and additional reserves of growth of production which were not previoulsy taken into consideration in plans for the seven-year period.

The Magnitogorsk Metallurgical, Kuznetsk and Nizhne-Tagil'sk Combines, and some metallurgical factories, once more testing their possibilities, assumed the duty of fulfilling one or two years in advance the tasks in the production of ferrous metals set for 1965.

The Central Committee of the Communist Party of the Soviet Union and the Council of Ministers of the USSR have approved the initiative of the Ukrainian SSR in taking measures which have assured the fulfillment of the Seven-year Plan for the growth of the ferrous metallurgy of the Ukraine in five years.

As a result of additional factors the tasks adopted for 1960 in the production of ferrous metals exceed the calculations taken into consideration in the preliminary figures. The plan for steel smelting has been increased by 2.9 million tons, the production of rolled iron by almost 2 million tons, of steel pipe by 275,000 tons and the mining of iron ore by more than 3 million tons.

The 1960 plan for the production of ferrous metals has been set in the following dimensions:

| | Million tons | % of 1959 |
|---|---|---|
| Cast iron | 47.07 | 109.6 |
| Steel | 64.92 | 108.5 |
| Rolled iron | 50.25 | 107.6 |
| Steel pipe | 5.85 | 113.1 |
| Iron ore | 105.5 | 111.9 |

In 1960 the increase in steel smelting alone will exceed the annual production of steel in Russia in 1913.

It is very indicative that, beginning in 1957, the year of reorganization of the administration of industry and construction, the absolute growth of production of ferrous metals has been increasing from year to year.

The rates of growth of cast iron and steel pipe production are also increasing.

*Increased production of ferrous metals in 1960 should* be assured basically on account of improvement in the utilization of operating aggregates and the inclusion of aggregates introduced in 1959. The production of metals in aggregates introduced in 1960 should amount to only 5% of the total growth for cast iron, less than 9% for steel and less than 15% for rolled iron.

Work must be done on a broad scale in 1960 in completing the program for speeding up the technical process which was adopted by the June Plenum of the Central Committee of the Communist Party of the Soviet Union, a plan for the development and introduction of new technique into ferrous metallurgical enterprises.

The basic tasks of the individual branches for 1960 are:

In blast-furnace production: further improvement in the preparation of materials for the smelting process, increased production of agglometate, raising its basicity and quality, increasing ore reserves and their appropriate neutralization, the introduction of natural gas and oxygen, elevating the blasting temperature and the pressure of blast-furnace gas.

In steel-smelting production: the introduction and raising the efficiency of the use of oxygen and compressed air, the replacement of riveted ladles by welded, increase in the yearly production of metal, reduction of the idle time of furnaces, increasing the weight of charges, mastering continuous casting, the smelting and casting of steel under vacuum, and improvement in the preparation of scrap.

In the production of cast iron and pipe: further increase in the productivity of cast-iron and pipe mills on account of increasing the rate of cast iron, improvement in the annealing of ingots, increasing the weight and improving the configuration of ingots and bars, reducing down-time of equipment; utilization of the new profiles and sizes and improving quality of cast-iron production and pipes to assure technical progress in the branches of the national economy which have requirements for metal; lightening the weight of machines and construction and reducing waste in metal working; fulfilling the resolutions relating to the growth of the pipe industry and the development of the thermal working of metal; the introduction of automation and the mechanization of processes, especially in work for increase of productivity and betterment of labor conditions.

The amount of capital investment in the growth of ferrous metallurgy in 1960 has been set at more than 13 billion rubles, of which construction work amounts to 8 billion rubles, with increase as compared with the expected inclusion in 1959 amounting to 26% and 19.5% respectively.

In accordance with the directives of the Twenty-first Congress of the Communist Party of the Soviet Union and the resolutions of the June Plenum of the Central Committee of the Communist Party of the Soviet Union, the *capital investments allotted to 1960 are directed only* to the expansion and reconstruction of operating enterprises of ferrous metallurgy and to the continuance of construction already started.

Of the total amount of capital investments for 1960, 50% is provided for the construction of metallurgical factories and 32% to mining enterprises. The capital investment for construction of objectives of the tube industry are increased over 1959 by 30.8%, and in factories producing metal articles by 220%.

In plants for concentration of material resources separable in 1960 in the draft of the plan from the total limit of capital investments, 67% was set aside for the construction of 28 very important ferrous metal enterprises, and in the starting objectives about 80% of the total amount of capital investments was provided for.

The basic task in ferrous metallurgy in 1960 is the construction of objectives assuring increase in capacity as regards the mining and enrichment of iron ore and the production of rolled iron and pipe.

It is proposed that six rolling mills be put into operation in 1960, whose total capacity will constitute 59% of the rolled-iron productive capacity put in operation during the seven-year period 1952-1958. Three sheet mills are being put in operation.

It is proposed to start up at the Magnitogorsk Combine the first series of continuous sheet mill 2500; at the Orsko-Khalilovsk Combine sheet mill 2800 will be introduced; and at the Il'ich metallurgical factory, mill 1700.

At the Cherepovetsk factory, construction will be completed of sheet mill 2800/1700, the first series of which (the 2800 line) was put in November, 1959. At the same factory the installation of a continuous billet mill is being completed. At the Novo-Lipetsk metallurgical factory it is proposed to put in operation the first series of works for cold rolling of electrotechnical steels.

In the Krivorozhe iron-ore basin it is proposed to speed up the construction of Southern ore-enrichment Combine No. 2, putting it in operation at a capacity of 9 million tons of crude ore in 1960 instead of starting up the first line (4.5 million tons) contemplated in the calculations and preliminary figures for the seven-year period; the first line of the Central ore-enrichment combine, with a capacity of 7.5 million tons, is also being put in operation.

At the Kursk magnetic anomaly, the Mikhailovskii pit is beginning to operate at a capacity of 2.5 million tons. In the Kazakh SSR the first line of the Sarbaisk

pit, with a capacity of 1,500,000 tons of crude ore is planned to be put in operation.

In the pipe industry capital investments are directed toward increase in the production of special-purpose pipe, the expansion of the assortment and improvement in the quality of pipe. A plant for hot pressing of pipe has been put in operation at the Pervouralsk and Nikopol'sk factories, and drawing mills at the Sinarsk and Zakavkazsk factories.

At the Makeevsk and "Svobodnyi Sokol" factories new capacities will be operated in the production of cast-iron pipe by the method of centrifugal casting.

In the metal articles industry, at the Beloretsk metallurgical combine and the Stalinsk and Khartsyzsk factories, it is planned to construct new works for the production of high-stability steel for the making of prestressed reinforced concrete construction.

The capacity of the refractory industry is being increased.

The metallurgists of the Soviet Union and builders of metallurgical factories are applying all their efforts and knowledge to solve the present problems in a creditable manner and to fulfill and over-fulfill the plan for 1960.

* * *

# CONCERNING NEW METHODS OF INTENSIFYING METALLURGICAL PROCESSES

Academician I. P. Bardin

Translated from Metallurg, No. 1, pp. 4-7, January, 1960

The present method of liquid-steel production had its origin more than one hundred years ago. It is a two-stage process consisting of smelting to pig iron in blast furnaces followed by treatment in open-hearth furnaces or converters. Its perfection and modification took the form of increased size of units, intensification of the smelting process and use of new raw-material and fuel resources.

World production of steel in open-hearth furnaces will, in a few years, reach half a billion tons per year. Yet, the conversion from the two-stage batch process to a single-stage continuous one (this includes obtaining steel in the blast-furnace crucible) remains a difficult problem; and this in spite of the attractive prospects of reducing metallurgical coke consumption, lower capital investment requirements, increase in labor productivity and other advantages. Serious attempts at solving this problem must begin immediately.

In the design of new metallurgical plants the design organizations strive to increase the size of the basic plant units – the blast furnaces, open hearths and converters.

Contemporary metallurgical plant units have, however, reached such a size that to enlarge them further, while keeping the old technology, will soon stop yielding the desired results.

Economic and technological advantages which may be achieved when constructing new plants are diminishing. What is gained in labor productivity, reduction in repair costs, etc., is less and less counterbalanced by the increased expenditures for larger lifting and transporting equipment and heavier supporting structures. The approach to modernization of the blast furnaces and steel-melting furnaces now being constructed should be such that they may be capable of most intense production; new methods of intensifying the processes should be found and old methods should be perfected.

In this connection I wish to put forward some thoughts concerning the possible advances in the engineering of steel-production processes in plants to be newly constructed.

It is not my intention to touch on problems concerning rolling and continuous casting of steel. The continuous-casting process is at present being proven-out on a large scale in production plants and this will soon permit correct and accurate conclusions to be drawn about the future of this process.

Use of blast furnaces with an active volume of 2,000 $m^3$, open-hearth furnaces with a charge capacity of 600-1,000 tons and discharging into two or three ladles, and top-blown converters with 125-150 tons charge capacity, is possible and advisable.

It is possible to increase the productivity of blast furnaces and steel furnaces without increasing their size by introducing the following: automatic control of the operation, further improvements in raw-material preparation, intensification of the process by raising operating temperatures, speeding up chemical reactions, etc.

Metallurgical plant practice of recent years has shown how very important for blast-furnace operation is the beneficiation of agglomeration of the ore feed, and also prior preparation of the charge. Concentration of ores to bring the concentrate iron content to 60-65% has been proven economically sound; no other efforts to improve blast-furnace technology have given such benefits as have concentration and agglomeration.

The effectiveness of the use of the self-fluxing agglomerate has also been proven. This is a solved problem.

The importance of preparing raw materials for blast-furnace use will grow even more when the size of the agglomerating units is increased. Specifically the working area of agglomeration machinery should be increased to 200 $m^2$. Then the capacity of one strand will be 5-6 thousand tons per day.

It is imperative that the pelletizing methods are developed fully. Pellets are porous and enable charging the blast furnace with material which is consistent not only in chemical composition but also in size.

During the past ten years numerous technical novelties have been introduced into metallurgy. Worth noting among them is the wide use of oxygen as the main process-intensifying agent and the replacement of various process fuels by high-calorific-value natural gas.

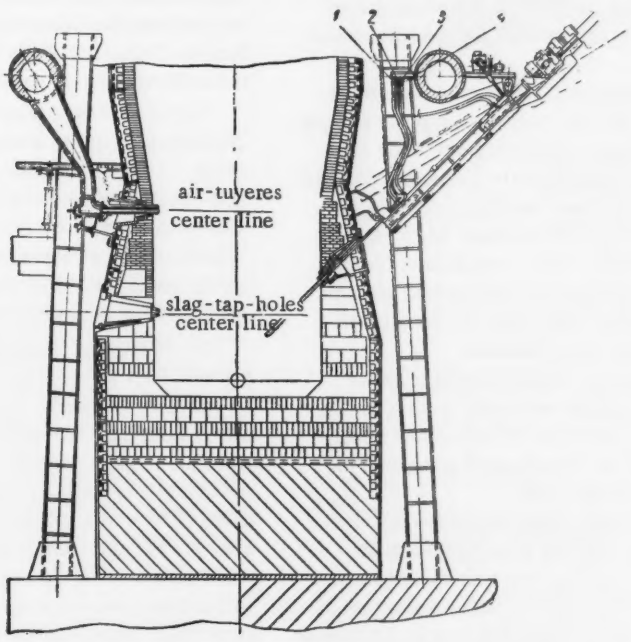
Yet, all possibilities have by no means been exhausted. There remains in part to be introduced: the use of oxygen in blast furnaces in the production of pig iron for steel manufacture, use of oxygen for preliminary refining of pig iron before pouring into steel smelting units, and also the solution of the problem of charging open-hearth furnaces and converters with a fully sulfur-free and silicon-free intermediate product at a high temperature.

When smelting pig iron for steel manufacture, oxygen content in the blast should not be increased beyond 24-25% because going beyond this figure does not give material advantages.

According to Professor V. P. Izhevskii's opinion, the distribution and movement of gases in the blast furnace can be compared to the flow of current through conductors. The latter is governed by Ohm's law according to which the magnitude of the current which distributes itself through parallel conductors is directly proportional to the potential difference and inversely proportional to the resistance of the conductors.

Variability of materials to be smelted in the blast furnace leads to an unstable smelting process. Channelling of blast in the charge increases this instability. Where reduced gas activity is needed the latter actually rises and vice versa. When we introduce oxygen by adding it to the blast and blow it in through the tuyeres we actually aggravate this instability of blast-furnace operation.

The investigations concerning condition of the charge at various levels in the blast furnace during the smelting process conducted by the Metallurgical Institute of the Academy of Sciences of the USSR, have shown that the untreated charge in the center of the shaft descends to a lower point when oxygen is used as compared to when none is used. This is actually the




Lower part of the blast furnace with the apparatus to blow pig iron with oxygen. 1) Water supply to tuyere; 2) water discharge from the tuyere; 3) oxygen supply to tuyere; 4) supply of powdered lime to tuyere.

cause of the difficulties that are known from the trials using an oxygen-enriched blast.

In our opinion, the oxygen should be introduced into the blast furnace by a different means and at a different pressure. The following should be tried: introduction into the blast furnace of pure oxygen at a pressure of 8-10 atm through special converter-type tuyeres mounted in such a way that the oxygen can penetrate to the furnace center. Oxygen would be introduced into the furnace through four inclined, extension-type tuyeres immersed into the slag and mounted below the blast tuyeres (see Figure).

It may be surmised that with such an introduction of oxygen, the blast-furnace crucible will not constitute merely a metal reservoir but be an active furnace component with an oxidizing atmosphere which would ensure oxidation of silicon, sulfur and partially (up to 2%) carbon.

Temperature in the crucible will rise by something like 200°; this, however, should not harm the crucible's strength nor its operating safety. When blast furnaces are rebuilt the project organizations regrettably do not introduce any significant changes into the crucible-cooling systems. I believe that air cooling the crucible and bottom, which a series of plants including "K.M.K." have begun to introduce, will in the future ensure safe crucible operation with the use of common high-alumina refractories. This task may be solved by the application of evaporator-type coolers for the bottom and side-guard plates.

There is the question whether continuous carbonization of pig iron by floating chunks of partially slagged coke would proceed more rapidly than oxidation of carbon in the pig iron. Experiments conducted in cupola furnaces have shown that under certain conditions the pig-iron-carbonization process proceeds less rapidly than the carbon oxidation. Thus, I consider it feasible to obtain in the blast furnace an intermediate product at a temperature of 1450° which does not contain silicon, and has a decreased sulfur content.

Consequently, 120,000-200,000 kcal per ton of pig iron which are lost in the two-stage process for the removal of the silicon and a part of the carbon would be used completely in the blast furnace and would enable saving up to 10% of the coke.

*Of course this proposal should be verified by means* of an experiment on an existing blast furnace after *modifying the latter according to a special design. It* should be pointed out that together with the oxygen and through the same path natural gas may be introduced into the blast furnace. Natural gas now is not utilized to the extent that it would replace a large part of the coke.

Modification of a blast-furnace crucible and development of its operation with oxygen and natural gas will open new possibilities not only for the blast-furnace process. The steel plants treating pig iron will receive their feed at a high temperature, and its use will enable a substantial rise in their productivity.

If, prior to construction of large blast furnaces and steel producing units, it were planned to operate them in the most intense manner possible, the makeup of the basic departments and the technological sequence would be changed.

For a 3.5-4 million tons per year plant it is sufficient to have three blast furnaces with a capacity of 1.5 million tons of pig iron per each year; four open-hearth furnaces with a 1,000 ton charge capacity, operating on hot metal and using oxygen in the flame and in the bath, and each producing up to 1 million tons of steel per year; or, depending on scrap availability, four converters with 125-150 ton charge capacity, top-blown with oxygen.

In such a plant pig iron will be sent from the blast furnaces to the open-hearth shop in 250-ton ladles. Use of such ladles will obviate the need for constructing mixers.

In a metallurgical-plant flow sheet the presence of mixers necessitates unproductive operations (lifting and pouring of pig iron) which cost a considerable amount of money. In its time the mixer played a useful role; at present it is feasible to transfer pig iron from the blast furnaces directly into the steel-refining furnaces and the need for mixers in the scheme ceases to exist. Such a scheme is already in operation in some plants in the USA.

When the makeup of a steel plant is decided upon it should not only be attempted to hold down to a minimum the capital investment and refractory consumption (which are achieved in the converter process) but also to simplify as much as possible the ingot-pouring operations. The converter produces regularly comparatively small batches of steel and this facilitates the organization of the rolling plants.

In concluding this paper the significance of finding new ways to intensify metallurgical processes must be stressed. Of course, it is not yet possible to say to what extent the blast-furnace operation will be modified when the proposed scheme of introducing oxygen into the crucible is made to work. The new technology needs to be verified under production conditions; thereafter the peculiarities of the process and its difficulties *will become plain. It can be predicted that this scheme* will reduce coke consumption by 10-15% while, at the same time, increasing the effectiveness of using natural gas. In addition the use of highly heated steel – furnace feed will significantly increase the rate of refining pig iron into steel. The capital requirements for construction of refining departments in metallurgical plants will be significantly reduced.

# NEW TECHNOLOGY OF PREPARING THE KERCH ORES FOR SMELTING

V. I. Karmazin, G. V. Gubin, A. V. Tsybenko, and A. M. Kucher

"Mekhanobrchermet"

Translated from Metallurg, No. 1, pp. 7-10, January, 1960

In order to ensure the uninterruptedgrowth of pig-iron and steel production, the rate of mining of Kerch ores must be sharply increased already in the present seven-year period.

The nature of the ore formations permits open-pit mining and use of high-capacity waste-removal bridges and multiclam excavators.

Kerch ores are very cheap: the net cost per ton is 2-4.5 rubles, whereas mining costs of taconites at the Southern Mining and Concentration Combine was 6.1 rubles per ton in 1957, and the cost of underground-mined Krivii-Rog ore is 16.4-23.2 rubles.

Because of the low costs of the Kerch ores it is possible to organize production on a very short term; more complex beneficiation methods should be stressed instead of washing, as presently applied, which raises the iron content in the ore by only 2-4%.

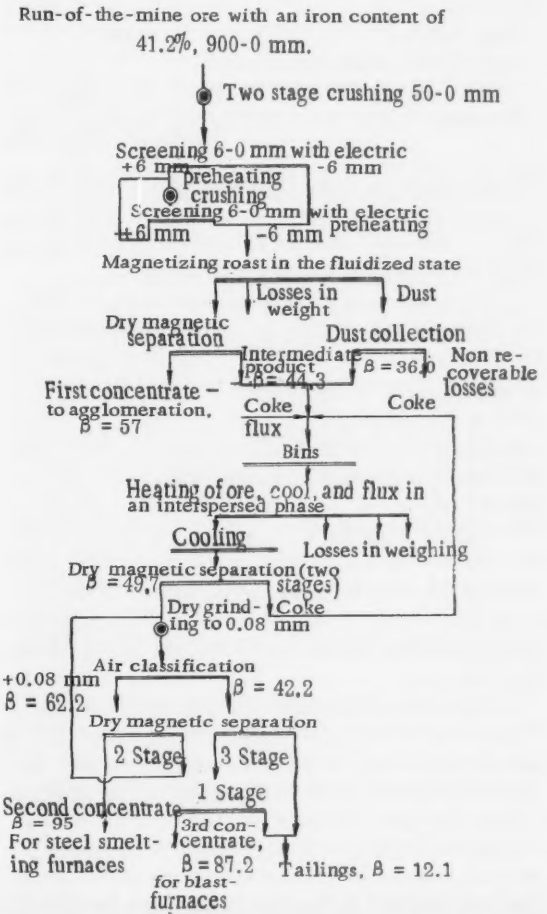
The basic reserves of Kerch ores have been developed only slowly up to now, largely because they are difficult to beneficiate and contain arsenic. Up to 70% of these ores are the so-called tobacco ores which consist of fish-roe shaped, clay-containing limonite, mixtures of clay-containing limonite and massive limonite or only massive limonite, bound together by a cement which consists of a sand-clay material containing nontronite and other water-containing aluminosilicates and also iron phosphates. The basic mineral is limonite and the fish roes consist of this. Limonite, to the extent of 25-30%, is also contained in the cementing medium. Iron content in the ore is 32-49%, manganese 0.35-3.5% and arsenic on the average, 0.1%.

In blast-furnace smelting the arsenic goes completely into pig iron and then into steel. Some investigators believe that the quality of steel containing over 0.2% arsenic is decreased; however, this question is not as yet clarified.

The proposed magnetizing-roast methods for concentrating tobacco ores remove arsenic to a significant extent but the concentrating process itself is inefficient, giving a relatively poor concentrate (51-56% Fe), and iron-rich tailings (21-27% Fe).

Lately at "Mekhanobrchermet" a concentrating process for Kerch ores was investigated which yields a high-grade low-arsenic concentrate on roasting in natural gas. A new flow sheet was proposed, based on the investigations (see figure).

The principal difference between the presently developed process and previously proposed ones is the fact




Concentration flow sheet for Kerch tobacco ores: β = iron content, %.

TABLE 1

Results of Magnetic Analysis of Kerch-ore Samples Calcined in a Fluid-bed Reactor

| Type of ore | Raw ore % | | Calcined ore % | | Products of calcined-ore magnetic separation, % | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Tailings | | | Concentrate | | |
| | Fe | FeO | Fe | FeO | Iron content | Weight yield | Recovery | Iron content | Weight yield | Recovery |
| Brown . . . . | 41.2 | 1.4 | 51.5 | 27 | 23.7 | 5 | 2.4 | 53.0 | 95,0 | 97.6 |
| " . . . | 41.3 | 0.5 | 49.6 | 16 | 16.2 | 6.0 | 2.0 | 51.7 | 94.0 | 98.0 |
| Tobacco-type. . . . | 41.9 | 3.6 | 49.1 | 13.4 | 22.2 | 8.5 | 4.0 | 50,6 | 91.5 | 96.0 |

Note: Samples of the brown and tobacco-type ores: 100 kg in weight, taken from the Black Sea or body.

TABLE 2

Decrease in Arsenic Content During the Magnetizing Roast

| Reducing agent | Type of ore | Duration of roast, min | Degree of arsenic removal, % | |
|---|---|---|---|---|
| | | | roasted ore | concentrate |
| Coke breeze . . . . . | Brown | 45 | 46.0 | 50.3 |
| Blast-furnace combustion products, containing 5% CO . . . . . | The same | 15 | 54.0 | 61.8 |
| The same . . . . . | Tobacco-type | 10 | 67.1 | 73.5 |

that the magnetic-separation tailings containing 25-30% Fe are not thrown away but sent to a second roasting stage at 1100-1200° in order to break down the iron-alumino silicates and produce metallic iron.

In the first stage of the investigations the raw ore was subjected to a reducing roast in the fluidized state. The fluid-bed furnace was a refractory lined cylinder, 400 mm in diameter, with a stainless steel grate onto which a layer of ore was charged. Products of combustion of natural gas were fed under the grate. When their velocity reached a predetermined value the ore layer was transformed into a pseudo-boiling state. The application of the fluidized state minimized internal and external resistance to diffusion which significantly shortened the ore-reduction time. Moreover, at increased gas rates the heat-transfer coefficient inside the active furnace chamber increased; this reduced the ore-heating time.

Experiments have shown that the most favorable degree of concentration was obtained when the following process parameters existed: roasting temperature – 700-800°, carbon-monoxide content – about 10%, and reduction time (including heating time) – up to 40 min. During the fluidized-bed magnetizing roast, hydrate moisture and dust were removed with the exhaust gases. The dust consisted in the main of the finest fraction of the cementing material.

As a result the iron content after roasting was higher by 8-12%. Results of magnetic concentration of fluid-bed-roasted Kerch ore samples are shown in Table 1. It was established that for very poor ores magnetic separation gave a significant effect in that it raised the iron content in the concentrate by 6-8%. If ores with an iron content greater than 40% were subjected to roasting, the effect of magnetic separation diminished; the iron content in the concentrate increased only by 1.5-3%. Numerous analyses of calcine samples showed that separation tailings contained 25-30% and concentrates 50-56% iron. The large iron losses may be explained by the fact that iron-aluminum silicates which form the bulk of the iron-containing phase in the tailings do not decompose at 700-800°.

In the process of investigating the magnetizing of Kerch ores, the arsenic-removal problem was also attacked. In Table 2 are shown the decreased arsenic contents resulting from the magnetizing roast, by means of a gaseous reducing agent in the fluidized state and by means of a solid reagent in the quiescent state. The degree of arsenic removal was indicated by comparing the As:Fe ratio in the roasted ore and concentrate to that in the ore. From the tabulated data it is seen that arsenic was removed from the brown Kerch ore significantly better upon heating in a weak reducing agent in the fluidized state than with a solid reducing agent in the quiescent state.

In addition to tests dealing with arsenic removal

TABLE 3

*Results of Ore Concentration*

| Feed material for direct reduction to iron | Iron content in the feed material, % | Degree of reduction $\frac{Fe_{metal}}{Fe_{total}} \times 100\%$ | Fineness of grind, mm | Total Fe in concentrate, % | Metallic Fe in concentrate, % | Total Fe in tailings, % |
|---|---|---|---|---|---|---|
| Brown ore . . . . . | 41.5 | 85.8 | 0.08 | 83.8 | 72.0 | 9.3 |
| Tailings from dry magnetic separation of roasted ore . | 31.0 | 77.4 | 0.08 | 91.0 | 87.2 | 4.3 |
| Tailings from brown-ore jigging. . . . . | 38.0 | 89.0 | 0.08 | 88.8 | 87.7 | 5.0 |

during the magnetizing roast, arsenic volatilization, by blowing steam through heated ore, was studied. For these tests 5-8 mm nodules made of tobacco ore particles of less than 0.5 mm in size were used. Iron content was 42.7%, arsenic 0.13% and the ratio $(As/Fe) \cdot 10^5 = 301$. The tests showed that the degree of arsenic removal rises with rising temperature and reaches 78% at 1000°C.

Consequently, it was shown in the first series of experiments, that, after the magnetizing roast, the high-grade oölite fraction of the ore may be separated into the concentrate and that a significant amount of arsenic may be removed. Moreover, in a unit which utilizes the fluid-bed principle the above processes can be intensified and capital investment for plant equipment may be reduced. Use in the fluid-bed furnaces of natural gas from the Anastasevsk deposit will contribute significantly to lowering the concentrate cost.

Since subjecting the Kerch ores to a magnetizing roast at 700-800°, followed by magnetic separation, does not yield tailings which are sufficiently low in iron, the second series of investigations had as its goal the development of a method of direct reduction to iron without melting.

The experiments were conducted in a reinforced laboratory rotary furnace consisting of a refractory-lined metallic shell into which was mounted a stainless-steel tube 200 mm in diameter, and tightly welded at one end.

Discharging ore and taking samples was accomplished periodically through the open end of the reaction tube, which was closed by a cover during the tests.

The feature of such a unit was the fact that blast-furnace-gas combustion products did not enter the reducing zone. This permitted a high (up to 80%) carbon-monoxide concentration to be maintained.

The charge, 5-0 mm in size and consisting of the ore, dolomite (calcite) and coke breeze (anthracite) was charged into the working zone after the furnace was heated to the required temperature. The reduction process was carried out at 1150°

The duration of experiments at a charge size of 5 kg was usually 3 hours. Samples were removed every hour.

After cooling, the reduced ore was ground and subjected to electromagnetic concentration on a permanent-magnet rotary separator. Results indicate (Table 3) that a concentrate containing 90% iron and a tailing containing 5% iron can be produced from the raw Kerch ore, and also from the magnetizing-roast tailings, and from jigging middlings.

Based on experimentation a new flow sheet for concentrating Kerch ores has been developed and is being submitted for pilot plant verification. It is described below.

Raw ore crushed to 5-0 mm is subjected to a magnetizing roast at 700-800° in a fluid-bed furnace where together with the magnetization of a part of the ore, a decrease in the arsenic content is obtained. The calcined, hot, ore is sent to dry magnetic concentration on drum-type separators, where the high-grade (up to 57%) oölites are separated out and are sent to the agglomeration step. Also produced is an intermediate product containing about 43% iron. The latter intermediate product and the dusts from the fluid-bed reactors are sent to direct reduction in a coal-flux interspersed phase at 1100-1200°. Use of natural gas is recommended for heating the ore in the interspersed phase, and also for reducing-agent production for the ore magnetization and arsenic removal. Product from the direct-reduction furnace is cooled and sent to dry magnetic separation to recover the excess solid reducing agent which thereafter is reused in the charge. The reduced-ore fraction is ground and electromagnetically separated in the dry state. From this a high-grade concentrate, containing 75-90% Fe (in this 70-85% is metallic), and a tailing containing 5-10% Fe are obtained. The high-grade concentrate is sent to briquetting and can be used for charging either steel-smelting furnaces or blast furnaces.

* * *

# INCREASING THE INTENSITY OF BLAST-FURNACE SMELTING

## From the Experience of Chinese Blast Furnace Engineers*

Abstracted by N. I. Krasavtsev

Translated from Metallurg, No. 1, pp. 10-12, January, 1960

The Chinese engineer Ma K'uang-k'ua has carried out an investigation to establish the possibility of increasing the intensity of blast-furnace smelting with simultaneous reduction in the specific consumption of coke.

Table 1 gives operating data for the No. 1 and 2 blast furnaces of the Taiyüan Plant, of capacity 151 and 301 $m^3$, respectively. It can be seen from the table that increase in intensity of smelting is accompanied by a reduction in the specific consumption of coke.

The Chinese engineers are of the opinion that the time spent by the materials in the furnace was not and is not a limiting factor and the increase in the specific consumption of coke, sometimes observed on increasing the intensity of smelting, is not due to the short time spent in the furnace but to the sudden deterioration in the distribution of the gas stream in connection with channel formation.

It is essential to improve the gas permeability of the charge in order to increase the intensity of smelting. Since the height of the column of charge materials is small blast furnaces is less than in large blast furnaces, the optimum intensity of smelting in small furnaces is always greater.

Being of the opinion that the gas permeability of the charge column depends on the quantity and properties of the slag, the Taiyüan engineers pay great attention to ore enrichment and to reducing the content of ash and sulfur in the coke (Table 2).

Exceptional importance is attached to the distribution of the gas streams and to the utilization of the chemical energy of the gas. At the Taiyüan Plant the best results on intensity of smelting and utilization of the chemical energy of the gases were obtained with a charge system which permitted a certain development of the peripheral and axial streams of gases (charging the coke first and keeping its weight low). Good distribution of the gases depends not only on the charging methods but also on the smelting intensity; with increase in intensity there is an increase in the disintegration of the charge.

Experience with the Taiyüan furnaces also shows that the speed of the blast has a considerable effect on the distribution of gas streams in the furnace. Table 3 gives data on the air speed at the tuyeres.

The work of leading blast furnace engineers in Communist China has led to the following conclusions.

1. Each blast furnace has its optimum intensity, depending on the charge conditions, technical supervision and the state of the equipment. At the optimum intensity, the best distribution of gases in the charge column is obtained and the lowest specific consumption of coke. Deviation from the optimum intensity in any direction leads to a deterioration in the gas distribution, to a lowering in the degree of utilization of their chemical energy and to an increase in the specific consumption of coke.

2. The gas permeability of the charge column and the smelting intensity are closely interconnected: With improvement in the gas permeability there is an increase in the optimum intensity and a reduction in the specific consumption of coke. The gas permeability of the charge column is largely determined by its sieve composition, uniform sizes, resistance of the coke to rubbing.

The production experience of Chinese blast-furnace engineers shows that under the existing conditions of operation, the intensity of smelting can be increased for average and small furnaces to 1.35 ton/$m^3$ · day and for large furnaces by more than 1.25 ton/$m^3$ · day.

3. Changing the methods of charging is one of the best ways of improving the gas permeability of the charge of smelting materials with constant charge conditions.

With increase in the intensity, the charging method was one which permitted a certain development of peripheral and axial streams. There was then an improvement in the gas distribution in the charge column and an increase in the utilization in the chemical energy.

4. The character of the gas stream in the axial zone of the smelting material column has an important effect on the operation of the furnaces and the specific consumption of coke. On clearing the axial zone and

*Abstract from the Czech Journal "Hutnické listy" (1959, No. 6) compiled from a translation by O. Kopechna.

TABLE 1

Operating Data for the Taiyüan Blast Furnaces in 1958

| Months | Furnace No. 1 | | | | Furnace No. 2 | | | |
|---|---|---|---|---|---|---|---|---|
| | Coef. of util. of useful volume $m^3$/ton | Intensity of smelting, ton/ $m^3$·day | Coke consumption kg/ ton iron | Iron content in ore, % | Coef. of util. of useful volume $m^3$/ton | Intensity of smelting, ton/ $m^3$· day | Coke consumption kg/ ton iron | Iron content in ore, % |
| January | 0.717 | 1.137 | 814 | 47.14 | 0.741 | 1.053 | 779 | 52.28 |
| February | 0.672 | 1.155 | 774 | 47.64 | 0.731 | 1.109 | 809 | 52.23 |
| March | 0.638 | 1.174 | 727 | 49.03 | 0.691 | 1.123 | 783 | 51.88 |
| April | 0.578 | 1.190 | 688 | 48.70 | 0.688 | 1.102 | 746 | 52.19 |
| May | 0.550 | 1.241 | 687 | 50.09 | 0.634 | 1.142 | 722 | 53.43 |
| June | 0.534 | 1.244 | 663 | 50.07 | 0.674 | 1.117 | 695 | 54.23 |
| July* | 0.871 | 1.051 | 783 | 50.13 | 0.627 | 1.181 | 727 | 53.46 |
| August | 0.580 | 1.181 | 689 | 50.00 | 0.646 | 1.180 | 763 | 53.46 |
| September | 0.437 | 1.402 | 613 | 51.34 | 0.527 | 1.219 | 691 | 54.94 |
| October | 0.414 | 1.434 | 593 | 50.60 | 0.509 | 1.372 | 690 | 53.60 |

*The reasons for the poor performance of the No. 1 furnace in July are not mentioned in the article.

TABLE 2

Content of Ash and Sulfur in the Coke Used in the Charge of Taiyüan Blast Furnaces

| Months 1957-1958 | Content in coke, % | |
|---|---|---|
| | ash | sulfur |
| September | 11.38 | 0.85 |
| October | 11.36 | 0.86 |
| November | 11.27 | 0.87 |
| December | 11.13 | 0.86 |
| January | 10.97 | 0.82 |
| April | 10.10 | 0.667 |
| May | 9.93 | 0.606 |

TABLE 3

Speed of Blast at the No. 1 and 2 Taiyüan Blast Furnaces

| Number of furnace | Inlet speed recommended by Soviet authors, m/ sec | Inlet speed when operating at low intensity, m/ sec | Inlet speed when operating with increased intensity, m/ sec |
|---|---|---|---|
| 1 | 70-100 | 62.78 | 73.24-75.39 |
| 2 | 70-100 | 59.72-61.78 | 69-70 |

increasing the amount of gases passing through it, there is an improvement in the treatment of the ore at the axis.

When the amount of blast and its input speed at the tuyeres are increased, the oxidation zone is extended and there is an increase in the amount of gases passing along the axis.

Reduction in the relative amount of slag permits an increase in the gas permeability of the charge and an increase in the amount of gases passing along the axial

These factors are very important in reducing the specific consumption of coke.

5. The operation of blast furnaces is characterized by the unevenness in the distribution of charge and gases across the section of the furnace.

Experience at the Taiyüan blast furnaces shows that the main problem is improving the distribution of the gas streams; the time spent by the materials and the gases in the furnace is not a limiting factor. Further reduction in this time does not increase the specific con-

sumption of the coke if the distribution of the gas in the furnace is improved.

Abstractor's Note. The above statements by the Chinese blast-furnace engineers that the time spent by the materials in the blast furnace is not a limiting factor at the present time and also the fact that under certain conditions the intensity of smelting can be increased to more than 1.25-1.35 ton/ $m^3$ · day without increasing the specific consumption of the coke, are not new for Soviet engineers. Many of them hold the same views and similar statements were printed some time ago. Nevertheless, the published comments by the Chinese workers are very important since some Soviet engineers consider that we have already reached the highest intensity, which lies somewhere between 1.0 and 1.1 ton/ $m^3$ and this limit cannot be exceeded without increasing the specific consumption of the coke under all conditions. The results given for the Taiyüan blast-furnace operation indicate that this view is erroneous.

* * *

# REPLACING THE IGNITION HEARTH OF A SINTERING MACHINE


## N. A. Belokonenko

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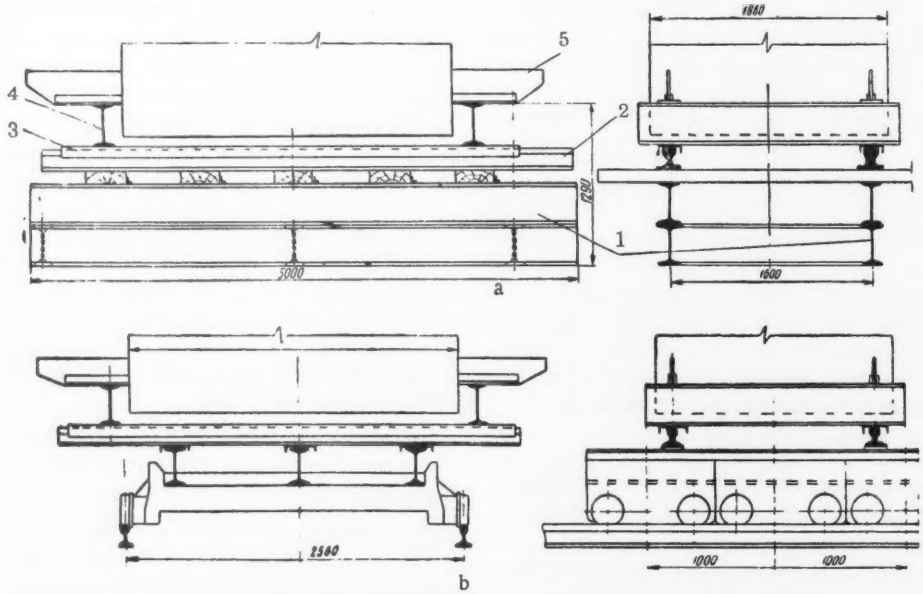
Translated from Metallurg, No. 1, pp. 12-13, January, 1960


The refractory lining of the gas-ignition hearth of a sintering machine is replaced approximately every 6 months. This process takes 1½ to 2 days and is usually carried out during regular maintenance or general overhauls of the sintering conveyer.

At the Krivoi Rog Steel Plant, in order to reduce the time of maintenance, the author has suggested that there should be a reserve hearth which can be put in place of the worn hearth by using a special device. The device (diagram) consists of a frame with crossties and rails. On the rails there are slideways with guide beams on which the hearth rests. During the replacement the slideways together with the hearth are drawn out by a




Device for replacing the hearth of a sintering machine: a) reserve hearth, located to the side of the sintering machine; b) hearth on pallets of sintering machine; 1) frame; 2) rails; 3) slideways; 4) guide beams; 5) dovetails of hearth.

winch until they are on the rails of the second frame, resting on 3 pallets of the sintering machine. The sintering machine is then switched to reverse travel and the hearth is set up at the place of assembly where it is lifted. The sintering machine is moved forward, the device is removed from the conveyer and assembly of the hearth commences.

The introduction of this method has reduced the repair time to 8 hours. The savings due to reduction in idle time are more than 50,000 rubles per year.

* * *

# INCREASING THE LIFE OF BASIC ROOFS AND CHECKERWORKS

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In 1957, two open-hearth furnaces at our plant were put into operation with basic roofs of chrome-magnesite brick. The roof was the supported-suspended type with the brick reinforced with cramp irons and plates.

The furnaces operate with the scrap-ore process and specialize in the production of rimming steels. The furnaces are fired with hot generator gas containing 10% addition of coke oven gas. A feature of furnace operation with generator gas is that the furnaces have to be stopped for 4-5 hours to clean soot from the flues and gas lines. Once during the campaign, the furnaces are stopped for 15-20 hours to clean soot and dust from the spaces under the checkerworks.

The life of the first basic roofs was 1½-2 times that of Dinas roofs but was still short and did not exceed 170-254 heats. With increase in the thermal loads on the furnaces with basic roofs the life of the checkerworks, especially the air checkerworks, was considerably reduced and the checkerworks did not provide the necessary life of the furnace with regard to the roof.

The results of an investigation into the character of the wear in basic roofs and checkerworks showed that the temperature of the basic roofs varied between 1450-1720°, overheating of the roofs above 1750°C was not observed. The temperature of the gas checkerworks was 1070-1180°, and that of the air checkerworks 1110-1270°; the air checkerworks were subjected to further heating above 1300°C. When the furnaces were stopped to remove the soot, the temperature of the roof was reduced to 900°C. The main reason for the short life of the roofs is that during the hot repairs and cleaning the brick flakes. After each soot cleaning and reduction of the roof temperature to 900°C, the working layer of brick flaked to a depth of 30-60 mm.

The flaking occurs due to reverse expansion of the brick at the areas containing a high proportion of iron oxides. Chemical analysis of the spent brick shows that in the working zone there is a sharp increase in the content of iron oxide whereas the content of magnesium oxides decreases noticeably (Table 1).

Due to absorption of iron oxides by the chrome-magnesite brick, the working zone swells, thus introducing additional stresses in the brick and causing flaking when there are sharp fluctuations in the roof temperature.

The first step in increasing the life of the roofs was therefore to heat the roofs during soot cleaning and hot repairs. For this purpose, an ejection burner was developed to feed coke oven gas through the end of the caisson (Figs. 1 and 2).

At a pressure of 3-4 atm the burner supplies 1500-1800 $m^3$/hr of gas to the furnace.

Before the furnace is stopped for soot cleaning, coke oven gas is turned on, after which air and generator gas are switched off. The gas and air valves and also the gate valve are closed. This keeps the heat in the working space due to combustion of the coke oven gas and the combustion products.

Heating of the roof during soot cleaning from the spaces below the checkerworks is only possible when there are open doors in the checkerworks and reliable overlapping of the vertical channels. The temperature of the roofs was kept at 1300°C by using burners, the life of the roofs then being increased to 350 heats.

The weakest spots in the basic roofs were the narrow sections and the inclined roofs of the heads due to their small radius and the low quality lining. Because of this, the seams between the rows opened, the roof warped, some bricks did not hold together and came out. To increase the life of these sections, the rise of the narrow sections and the roof of the heads were lifted by 150 mm. This increased the thrust forces in the rings of the roof and made it possible to improve the quality of the lining.

The burning of the roof under the front walls and especially near the third charging window is due to cold air being drawn in when the charging doors are open. To eliminate this it is recommended that the time during which the doors are open should be reduced.

As the result of measures which have been introduced, the life of basic roofs has now been increased to 400 heats with an increase in furnace productivity of 3-5%.

To increase the life of the checkerworks, their upper rows are lined with Dinas chromite, chrome-

TABLE 1

Change in the Content of Oxides in the Roof Brick

| Zone | Content of oxides, % | | | | |
|---|---|---|---|---|---|
| | FeO | MgO | $Cr_2O_3$ | CaO | $SiO_2$ |
| Working . . . . . | 39.0 | 28.0 | 6.5 | 3.7 | 4.0 |
| At a depth of 29-60 mm | 9.8 | 73.0 | 7.0 | 2.0 | 6.0 |
| At a depth of 60-180 mm | 6.4 | 74.0 | 6.5 | 1.5 | 6.5 |

TABLE 2

Physicochemical Properties of Refractories Used for Checkerworks

| Refractories | Grade | Refractoriness, °C | Porosity, % | Chemical composition, % | | | |
|---|---|---|---|---|---|---|---|
| | | | | $SiO_2$ | MgO | $Cr_2O_3$ | $Al_2O_3$ |
| Dinas-chromite . . . . . | MP-4 | 1690 | 17.6 | 84.0 | – | 6.5 | – |
| Chrome-magnesite . . . . . | MKhS-3 | 1750-1800 | 18-24 | – | 69-75 | 8-18 | – |
| Fireclay . . . . . | PM-60 | 1670 | 30 | 64 | – | – | 32 |
| Forsterite . . . . . | F-3 and F-4 | 1800 | 18-30 | 32 | 54 | – | – |

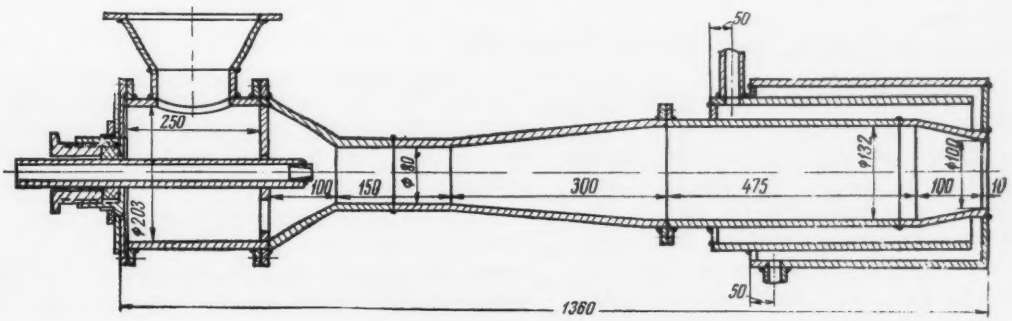


Fig. 1. Ejection burner for heating the roof during hot repairs.

magnesite, fireclay, and forsterite refractories (Table 2).

The checkerworks are laid in open channels with 150 x 150 mm cross section of the sections. There were 28 rows in the checkerworks.

The checkerworks of Dinas-chromite brick lasted 6 campaigns. In the furnaces with Dinas roofs, the life of the air checkerworks was 250 heats, and in furnaces with basic roofs, in view of the higher thermal loads, the life was reduced to 170-200 heats. The upper 2-3 rows usually fused with the formation of holes in the checkerworks; the 4-7 rows were slightly fused and were eroded by the fusion products. The life of the 8-11 rows was satisfactory. The fireclay brick formed a slag with the fusion products.

It has therefore been established that the Dinas-chromite brick in the upper rows of the checkerworks,

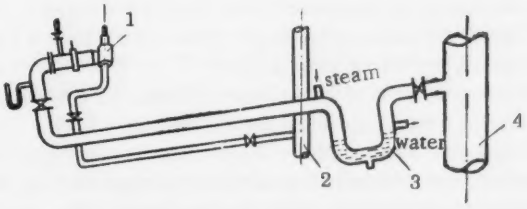


Fig. 2. Arrangement for feeding coke oven gas and compressed air to the ejection burner, mounted in the head of the open-hearth furnace: 1) burner; 2) compressed air pipe; 3) water trap; 4) coke oven gas pipe.

although it has shown a longer life than Dinas brick, is unsuitable for furnaces with basic roofs since it does not give a durable roof.

Tests on fireclay brick in furnaces with basic roofs showed satisfactory life: up to 400 heats.

During operation, fireclay brick forms a dense slag containing 45% $SiO_2$, 33% FeO and 5% $CaO + Cr_2O_3$. Because of the lack of fireclay brick at the plant, chrome-magnesite brick was tried in the upper rows of the air checkerworks. With these checkerworks the furnaces operated for 4 campaigns, the life of the checkerworks was increased to 252-309 heats. During service the chrome-magnesite brick swells due to absorption of iron oxides and forms a friable slag.

In the last 3 campaigns the upper 6-7 rows were laid with forsterite brick. The life of the air checkerworks was 400-420 heats. The upper rows of forsterite form a dense slag similar to high-alumina brick.

Observations have shown that for normal furnace operation with basic roofs it is essential: a) that the upper 6-7 rows of air checkerworks be laid with forsterite brick or fireclay refractories; under the forsterite checkerworks, 8-9 rows should be laid with Dinas and 12 rows with fireclay; b) that the upper 5-6 rows of gas checkerworks be laid with fireclay brick.

The use of these refractories has produced a checkerwork life of up to 450 heats, and the brick from the lower rows can be used for a second lining.

* * *

# THE USE OF MANGANESE ORE IN THE SCRAP PROCESS WITH LOW-MANGANESE IRONS

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Translated from Metallurg, No. 1, pp. 16-18, January, 1960

The open-hearth department of the Liepaisk "Sarkanais Metalurgs" Steel Plant smelts steel of normal quality corresponding to GOST 380-50, mainly rimming steels grades St. 1, St. 2, St. 3. The ingots are rolled in a section mill to medium section and wire rod. The basic open-hearth furnaces, equipped with Dinas roofs and Merts heads, operate the scrap process. The fuel is hot generator gas from coal of the Silesian coal basin (Poland). The coal is gasified in semimechanized gas generators of the Hilger system; the calorific value of the gas entering the open-hearth furnaces is 1300-1350 kcal/$m^3$, containing up to 1.5 g/$m^3$ sulfur.

Since 1957 the open-hearth department has received low-manganese irons with a manganese content which has gradually reduced from 0.90% to 0.11-0.20%. In 1958 the open-hearth furnaces operated exclusively on irons containing not more than 0.20% Mn. The content of other elements (silicon, phosophorus, sulfur) in the low-manganese irons was the same as usual.

In the conversion of low-manganese irons, the content of manganese in the metal during smelting is 0.09-0.12%, and the slag contains 6-7% MnO, whereas in the conversion of conventional iron in the first sample of metal there is 0.20-0.25% and in the slag from 8-10% MnO.

Smelting with a low-manganese content has increased the consumption of ferromanganese in the deoxidation of the metal. With the use of low-manganese irons there has been a noticeable increase in the sulfur content in the metal during smelting. Under the operating conditions of the "Sarkanais Metalurgs" open-hearth furnaces it is reasonable to assume that a source of sulfur saturating the metal during smelting is generator gas. Previously, when using an iron in the charge with a manganese content of 1.5-2.5%, the conversion of sulfur from the gas to the metal was not observed in noticeable quantities.

In this case the increased manganese content in the charge, and consequently in the metal and slag, had obviously prevented to a certain extent the active conversion of sulfur from the gaseous phase to the metal.

The removal of sulfur from the metal during smelting in amounts exceeding 0.010-0.015% presents considerable difficulties in our open-hearth furnaces: The thermal power of the furnaces is insufficient for intense desulfurization due to the use of low-calorie generator gas as the fuel; the use of slags with basicity greater than 2.5 introduced difficulties in the transfer of heat from the flame to the bath; for a number of reasons it is not possible to tap the primary slag in sufficient quantities. The coefficient of sulfur distribution between the slag and metal $L_S = (S)/[S]$ for our open-hearth furnaces hardly exceeds 5-6.

The high sulfur content in the metal during smelting with insufficient manganese in the charge therefore led

Classification of Heats in 1958 in Accordance with GOST 380-50

| | Months | Heats produced | Those accepted by the testing laboratory for sulfur | | | |
|---|---|---|---|---|---|---|
| | | | according to group B | | according to group A | |
| | | | heats | % | heats | % |
| Without manganese ore | January ..... February ..... March ..... April ..... August ..... | 891 | 707 | 79.4 | 184 | 20.6 |
| With manganese ore | May ..... | 166 | 137 | 92.5 | 29 | 7.5 |
| | June ..... | 173 | 154 | 89.0 | 19 | 11.0 |
| | July ..... | 161 | 151 | 93.8 | 10 | 6.2 |
| | September ..... | 201 | 193 | 96.1 | 8 | 3.9 |
| | October ..... | 173 | 152 | 87.8 | 21 | 12.2 |
| | November ..... | 166 | 159 | 95.8 | 7 | 4.2 |
| | December ..... | 214 | 210 | 98.1 | 4 | 1.9 |
| | Total for the 7 months .... | 1254 | 1156 | 92.2 | 98 | 7.8 |

to a higher sulfur content in the finished metal than that specified in GOST 380-50.

Observations have established the favorable effect of manganese on the desulfurization of the metal during the boiling period. Thus, the distribution coefficient of sulfur $L_S$ between the slag and metal increases with increase in the manganese content in the metal. The temperature of the flame is naturally an important factor. The active reduction of manganese during smelting and its high content in the metal before deoxidation lead to a reduction in the sulfur content in the metal in most cases.

In order to enrich the charge with manganese, since the middle of 1958 all heats are smelted with manganese ore in the charge. The ore contains 40.0-63.2% MnO and 14.6-20.0% $SiO_2$. The manganese ore in quantities of 0.3-0.5 tons is charged into the furnace together with the limestone. In cases where the metal contains 0.15-0.18% Mn during smelting and 0.068-0.070% during the finished period of smelting, 100-200 kg additions of manganese ore are made instead of iron ore. There is then an increase in the manganese content in the metal and usually a sharp reduction in the sulfur content. The total consumption of manganese ore is therefore about 15 kg/ton of cast steel.

Using manganese ore has led to a more then $2\frac{1}{2}$-fold reduction in the number of heats produced with high sulfur content (see Table). Smelting with high manganese content does not prevent active decarburization of the metal; the manganese content in the metal before oxidation in some cases is sufficient to allow tapping the heat without adding ferromanganese.

In all cases the consumption of ferromanganese in heats with manganese ore is less than in cases where manganese ore is not used. Thus, in January, February and March of 1958 (before using manganese ore) the actual consumption of ferromanganese was 8.8, 10.4 and 7.2 kg/ton of cast steel respectively. When using manganese ore the consumption of ferromanganese did not exceed 5.4 kg/ton steel, and in some heats it was not more than 3 kg/ton. On the whole during 1958 due to the use of manganese ore, the consumption of ferromanganese was 6.1 kg/ton of steel, compared with 8.8 kg/ton in the first quarter of 1958.

The following conclusions can therefore be drawn:

1. Enriching the slag by using a charge containing 1-1.5% of manganese oxide should be considered an efficient means of activating the desulfurization of the metal.

2. In the conversion of low-manganese irons in cold operating open-hearth furnaces it is advisable to add the manganese ore during the finish period of smelting also. The resulting increase in manganese content is accompanied by a reduction in sulfur.

3. The use of manganese ore in open-hearth smelting reduces the consumption of ferromanganese for the deoxidation of the steel by 38.6%.

# BUILDING OPEN-HEARTH DEPARTMENTS WITH A BLOCK-ISLAND LAYOUT OF THE FURNACES

I. D. Vikhrev and I. A. Afonin

Gipromez

Translated from Metallurg, No. 1, pp. 18-22, January, 1960

Extensive use has recently been made of large open-hearth furnaces of 500-ton capacity and above. Figures for the development of the national economy during the period 1959-1965, laid down by the Twenty-first Congress of the Communist Party of the Soviet Union, envisage an average annual increase in steel smelting during the seven-year period of about 5 million tons. This increase must be achieved by increasing the productivity of the existing open-hearth furnaces and by building new powerful furnaces. The equipping of large-capacity furnaces has led to a search for new systems for planning the open-hearth departments. A new arrangment has now been developed for planning the department with a block-island layout of the furnaces for one of the steel plants which is currently being built (Figs. 1 and 2).

Gipromez has compared the technical and economic features of open-hearth departments with linear and with block-island layouts of 8 furnaces of 500-ton capacity. This comparison has shown that with the block-island system with one teeming platform the output of the department can be more than 3.2% higher than with the linear arrangement. This is achieved by reducing the smelting time by 18 minutes. Furthermore, the productivity of a department with block-island arrangement of the furnaces with the construction of two teeming platforms for one block can be increased by approximately 10% by eliminating holdups in the pouring of steel due to the heats coinciding. It is reasonable to assume therefore that the productivity can be increased by 13.2%.

The main building with the linear arrangment of furnaces has 3 sections.

The department with block-island arrangment of the furnaces consists of 4 separate double-flight blocks; instead of the charge section there is only a wing of width 6.0 m, where the control panels are situated. The cars with the charge come directly into the furnace section, the mold cars remain at the end of the main building on the scaffold bridge where there are additional railway lines. When building the second teeming platform in the block, provision is made for the extension of the teeming section by 48 m to one side and 36 m to the other side.

A comparison of the data given in Table 1 shows that in the main building of the department with the block-island arrangement, one furnace has more crane equipment, the cost of which for the whole department is about 8 million rubles. The extra power of the

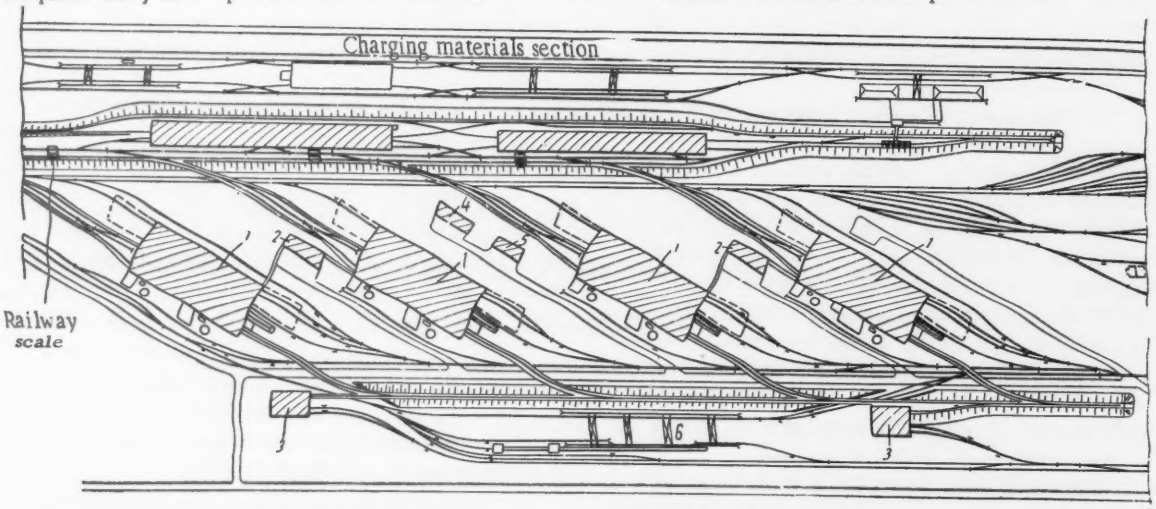
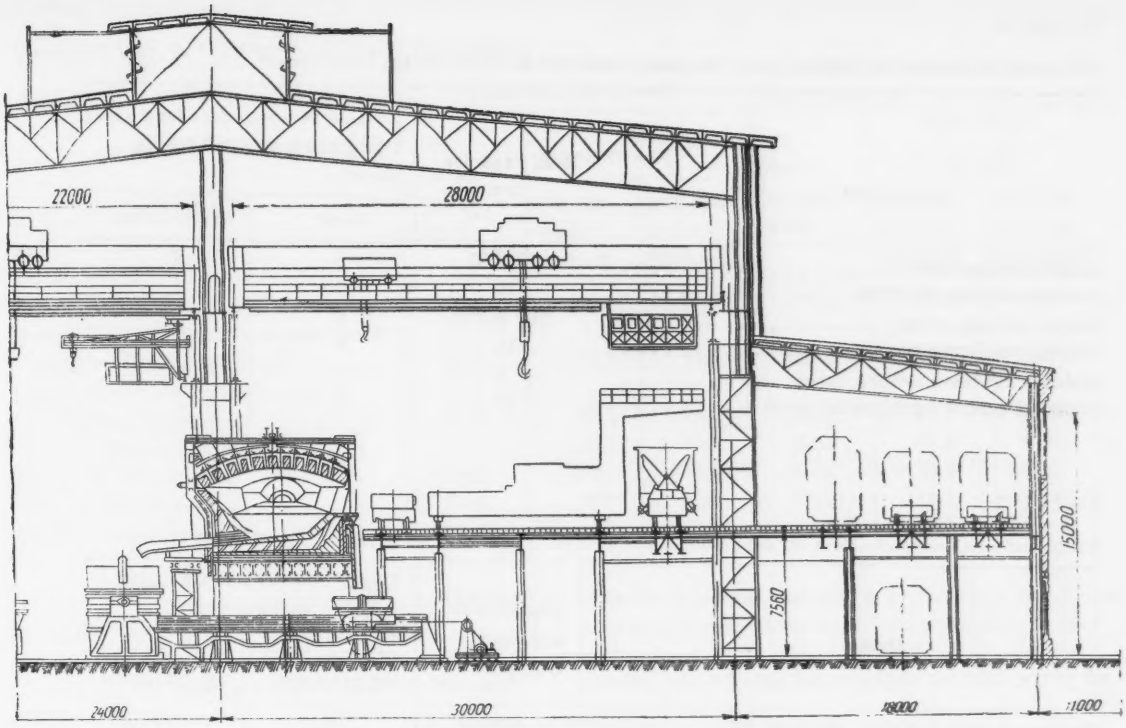



Fig. 1. Planning of an open-hearth department with block-island layout of the furnaces: 1) block of main body; *2) worker's accommodation; 3) mixer section; 4) repair shop; 5) laboratory for rapid analyses; 6) slag yard.*

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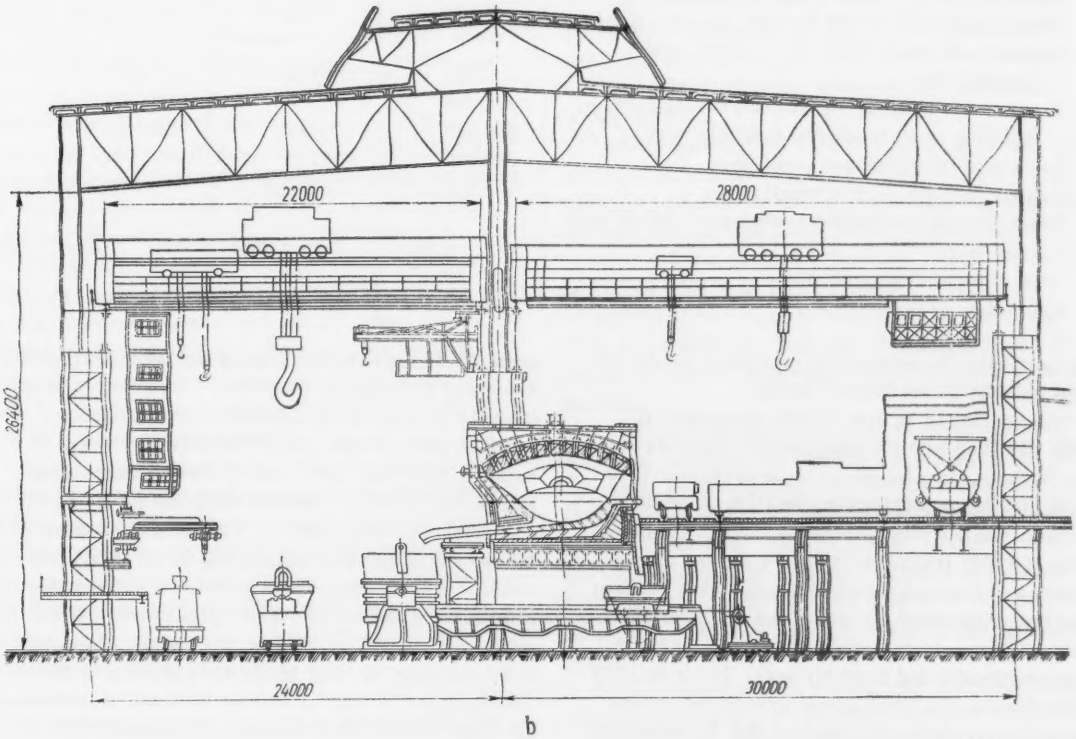


b

Fig. 2. Cross sections through the main building of an open-hearth department; a) with linear arrangement of the furnaces; b) with block-island arrangement of the furnaces.

TABLE 1

*The Required Amount of Hoisting and Transport Equipment in Open-Hearth Departments*

| Equipment | Load capacity, tons | Amount of equipment for a given arrangement of the furnaces, pieces | |
|---|---|---|---|
| | | linear | block-island |
| Bridge casting crane | 180/50 | 5 | 8 |
| Ground-charging machine | 10 | 6 | 8 |
| Bridge teeming crane | 350/75/15 | 8 | 8 |
| Mobile cantilever crane | 10 | 4 | 4 |
| Mobile cantilever slewing crane | 3 | 8 | 8 |
| Monorail trolley for repairing crane | 10 | 5 | 8 |

TABLE 2

Technical and Economic Data on the Construction of Two Types of Open-Hearth Departments

| Data | Department with linear arrangement | Department with block-island arrangement | |
|---|---|---|---|
| | | with one teeming platform | with two teeming platforms |
| Volume of main building, thousand $m^3$ | 1272.5 | 1062.0 | 1288.0 |
| Productive area of main building, thousand $m^2$ | 45.7 | 34.5 | 42.6 |
| Annual production of one furnace, thousand tons | 450 | 465 | 510 |
| Annual production of furnace in usable ingots, thousand tons | 3600 | 3720 | 4080 |
| Total cost of building department, thousand rubles | 370,022 | 380,974 | 388,974 |
| Including construction and assembly work | 230,287 | 232,630 | 240,630 |
| Labor used on department, man-days | 988,000 | 995,000 | 1,030,000 |
| Capital costs per 1 ton of steel, rubles | 103.0 | 102.0 | 95.0 |
| Labor costs of construction workers per 1 ton of steel, man-days | 0.274 | 0.267 | 0.251 |
| Area of department, hectares | 50 | 54 | 54 |
| Coefficient of building, % | 33.8 | 35.2 | 37.1 |

equipment helps the workers and provides a reserve for further increase in the furnace charge.

The building of an open-hearth department is usually bound up with the equipment of other units (blast furnaces, sintering plants, coke ovens, etc.). A typical plan for organizing the operation of the department with linear arrangement of the furnaces therefore envisages a long interval between the periods of inauguration of the open-hearth furnaces. After the start of the first open-hearth furnaces there are usually a number of faults which complicate and add to the cost of the construction and assembly work. In the building of departments with block-island arrangement of the furnaces the recommended standard plan for organizing the work can be used in its entirety when constructing the main building. Due to the more convenient planning of the department, providing normal conditions of operation in the existing furnaces and those being built, and also a reduction in the width of the charging length (from 18 to 6 m), many drawbacks are eliminated.

The block-island plan provides for the supply of building loads from both sides of the building, regardless of the number of furnaces which are in operation and which are being built. It is no longer necessary to seal up the foundations and circuits of the subsequent stages in the building, which means that it is possible to reduce the amount of uncompleted production and reduce the capital costs on the starting procedure. It is not necessary to build temporary end walls to the building after starting up the new furnaces. Furthermore, the block-island system excludes the necessity for manual excavation and securing trenches.

Reducing the width of the building of the main body improves the conditions for assembling the con-

TABLE 3

Amount of Work in Building Open-Hearth Departments

| Operation | Total volume of work | | | Specific volume of work per one ton of steel, % | | |
|---|---|---|---|---|---|---|
| | linear arrangement | block-island arrangement | | linear arrangement | block-island arrangement | |
| | | with one teeming platform | with two teeming platforms | | with one teeming platform | with two teeming platforms |
| Excavations, thousand $m^3$ | 908.0 | 999.5 | 1029.5 | 100.0 | 106.2 | 99.5 |
| Concrete and ferroconcrete monolithic constructions, thousand $m^3$ | 79.0 | 75.0 | 78.7 | 100.0 | 92.0 | 88.0 |
| Ferroconcrete prefabricated constructions, thousand $m^3$ | 21.2 | 23.5 | 24.0 | 100.0 | 107.6 | 99.9 |
| Steel contructions, thousand ton | 42.1 | 38.0 | 40.4 | 100.0 | 87.2 | 84.6 |
| Length of railways, km | 29.5 | 34.7 | 34.7 | 100.0 | 113.6 | 103.5 |
| Area of roadways, $m^2$ | 5000 | 9100 | 9100 | 100.0 | 125.0 | 113.6 |
| Scaffold bridge approaches, $m^2$ | 12,288 | 15,820 | 15,820 | 100.0 | 125.0 | 113.6 |

structions and means that one tower crane is sufficient for all the work.

It can be seen from the figures given in Table 2 that the cost for building a department with the block-island arrangement, due to the increased amount of work on equipping the scaffold bridge, railways and roadways and also the water and power systems, is somewhat higher. However, an increase in the output of the open-hearth furnaces by only 3% makes up for the capital expenses for 1 ton of steel for departments with different arrangements of the furnaces. In the construction of open-hearth furnaces with block-island arrangement of the furnaces having two teeming platforms, the capital expenses for 1 ton of steel are reduced by more than 7%.

The absolute labor costs of building departments with linear and block-island arrangements of the furnaces are practically the same. The specific labor costs of the building workers per 1 ton of steel with the block arrangement of furnaces and with one teeming platform is 3% less, and with two teeming platforms it is 8% less than with the linear arrangement.

It can be seen from Table 3 that the absolute amount of excavation work and also work on assembly of prefabricated ferroconcrete constructions and the equipment of railways and roadways for departments with the block-island arrangement of furnaces is somewhat higher than for shops with a linear arrangement, and as regards steel and monolithic ferroconcrete constructions it is somewhat lower.

A fault of the block-island arrangement in an open-hearth department is the increase in the operating personnel due to the increased amount of equipment for one furnace, which leads to an absolute increase in the operating costs. Furthermore, it has not yet been checked in practice whether it is possible to keep loaded cars on the open tracks of the scaffold bridge; it may prove necessary to build additional shelters over the tracks, thus reducing the economic effectiveness of the block-island method.

The main advantages in planning a department with the block-island system is that the output of the open-hearth furnaces is increased. In a department with linear arrangement of the furnaces, the increase in output is limited by the output of the furnace and casting sections.

When expanding the converter production, the block-island planning of the department makes it possible to build open-hearth and converter blocks in any order and with any output. The block-island arrangement of furnaces puts practically no limit on the increase in new capacities since with the simultaneous building of several blocks it is possible to put any number of furnaces into operation. This type of planning makes it possible to build a department with high-speed flow methods.

The block arrangement of the furnaces provides favorable conditions for carrying out rapid repairs, especially when replacing 500-ton furnaces by those of larger capacity, which will be very important in the future. Under these conditions, it is possible to carry out preliminary reinforcing and assembly of the body of the furnace at the end or at the side of the building with subsequent pushing or lifting by crane to the planned position.

The arrangement of a general plan and design solution for the building of the main body with block arrangement of the furnaces provides a good basis for extensive use of industrial construction methods when building steel-smelting shops. This arrangement con-

forms entirely with the principle of having a general plan for a steel plant from the center to the periphery without leaving "white" spots for further development of the departments.

The building of open-hearth departments in separate blocks is very advanced in both technical and constructional features.

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# REDUCING FURNACE SHUTDOWNS ON BURNING-IN

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In the open-hearth department of the Uzbek Steel Plant a method has recently been developed for improving the burning-in of new hearths and preventive repairs. The measures have reduced the holdups in repairing the hearths to 1.9-2.16%.

The open-hearth furnaces of the plant work on the scrap process and are fired by oil with a calorific value of 9000-9500 cal/kg. The furnaces have chrome-magnesite roofs.

As a rule, the furnace hearth is repaired at a time which is agreeable to the workers of the mechanical and electrical service departments, which means that preventive repair of the equipment can be carried out at the same time as the repairs on the hearth.

The preventive repair of the hearth is preceded by thorough preparation, which is the best guarantee of successful and rapid burning-in. Before tapping the last heat before the repair, a magnesite powder is prepared on the working platform, this powder having the appropriate chemical and granulometric composition, largely free of mechanical impurities of scale (94.5% FeO, 0.67% $SiO_2$). The magnesite powder contains about 85% MgO, 3.85% CaO, 5.5% $SiO_2$.

A 1.0-1.25 inch diameter pipe is used to blow residues of metal and slag from the hearth. Compressed air is fed in at a pressure of 5-5.5 atm.

The hearth is repaired by various methods, depending on the depth of the obstruction. An obstruction of depth 100-150 mm is blown out by air through two pipes in one stage. If the obstruction is in the middle of the bath the hearth is dried from the edge doors without waiting for the end of the blowing-out. The drying lasts no longer than 20 minutes. The hole is then closed; the maximum amount of fuel is then fed to the furnace and after heating the lining of the working space to 1600°C the first layer is poured to a depth of 70-100 mm. During the heating of the poured layer (for 1 hour) the inclines, front and back walls are dressed. The total time for pouring the layer, heating and dressing the furnace is 100-120 min. The hearth is then treated with scale, the consumption of which is about 20% in relation to the volume of the used magnesite powder. Slag which has collected on the hearth is tapped off and the first heat is charged without cooling the hearth. The total length for this type of hearth repair is between 3 hours and 3 hours 20 minutes.

With extensive wear in the hearth, when the depth of the obstruction reaches 150-200 mm, the obstructions are blown out in two stages with intermediate heating of the furnace for 15-20 min. The time for blowing out, drying and closing the hole in this case is 50-70 min. In the low spots of the hearth, magnesite powder is poured to a half of the depth which is covered with layer of scale (5-7%). At the same time, a layer of magnesite powder is poured uniformly over the whole of the hearth without treatment with scale. After the layer is heated (30-35 min) during which the inclines, front and back walls are dressed, a second layer is added of thickness 50-60 mm. This layer is heated for 50-60 min. The hearth is then treated with scale (15-20% of the weight of magnesite powder used in the second layer), the slag is tapped and the charge materials for the next heat are added. The total time for this repair is 4-5 hours.

After the general overhaul, the new hearth was burnt in with the following method.

After the furnace had been heated, the hearth was intensely slagged, the slag for this purpose being of the following chemical composition, %:

FeO – 10-11; MnO – 4.5-5.5; MgO – 10.2-11.0; $Al_2O_3$ – 3.2-4.0; CaO – 44-45; $SiO_2$ – 20-21; RO+ + $R_2O_5$ – 7-8.

The size of the slag particles varied from 10-40 mm. The time for slagging was 4½ hours.

After tapping the slag for 20-25 min, the first layer of about 55 mm thickness was poured from one magnesite

powder. After heating (5 hours), this layer was treated with scale (20-25% of the powder used), after which the layer was heated again for 2 hours. Before adding each successive layer, samples of the hearth were taken, the analyses of which are given in the Table.

The second and third layers of up to 55 mm thickness were also provided by one magnesite powder with subsequent treatment with scale.

The fourth layer of thickness 75 mm was heated for 6 hours, after which it was treated with scale and again heated for 2 hours.

The total duration for burning-in the new hearth was 35 hours 30 minutes. The thickness of the burnt-in section was 240 mm. The hearth burnt-in with the new method has good durability. The first preventive repair was carried out after 60 heats.

Analysis of Hearth Samples by Layers

| Layer | Chemical composition, % | | | | |
|---|---|---|---|---|---|
| | MgO | CaO | $SiO_2$ | FeO | $P_2O_5$ |
| I | 62.94 | 9.35 | 7.86 | 10.9 | 0.096 |
| II | 61.56 | 8.25 | 6.6 | 8.78 | 0.099 |
| III | 63.51 | 5.38 | 6.84 | 12.98 | 0.052 |
| IV | 51.36 | 5.22 | 5.08 | 24.95 | — |

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# RESERVES FOR INCREASING THE LABOR PRODUCTIVITY IN AN OPEN-HEARTH DEPARTMENT


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In recent years, the No. 2 Open-Hearth Department has been constantly increasing its labor productivity. Compared with 1950, the production of steel has increased by 42.7%, the steel from 1 $m^2$ of hearth area has increased by 23.5%, and there have been considerable reductions in the idle time in the open-hearth furnaces. Whereas in 1950 the idle time comprised 9.1%, in 1957 it was 8.2% and in 1958 only 6.7%; for the 9 months of 1959 it was 6.5%. The smelting of steel per worker has increased by 54% during this period.

The increase in the amount of smelting (in tons) per worker during recent years is shown by the following figures: 1953 – 240.2; 1954 – 255.4; 1955 – 277.4; 1956 – 295.5; 1957 – 302.4; 1958 – 302.7.

The increase in the labor productivity in the department was achieved by better use of the existing units and the redesigning of furnaces and also by mechanizing laborious production processes.

The increase in steel production in recent years has been achieved mainly due to the conversion of open-hearth furnaces to heat-resistant chrome-magnesite roofs, changing the furnace dimensions, increasing the charge and volume of ladles, improving the labor organization at the charge yard and in the casting bay, changing the furnaces to oil firing, using high-alumina brick for the checkerworks and increasing the volume of the regenerators.

Since 1950 the department has incorporated more than 100 suggestions aimed at improving the labor conditions and the mechanization of laborious processes. The most effective of these are the following.

1. The mechanization of the addition of weighed portions of deoxidants to the furnaces and in the casting bays in the molds and hoppers.

2. Mechanizing the closing of the steel tapping hole of the furnace by means of a special attachment.

3. Two-stopper pouring of the steel from the pouring ladle. At the present time work is being carried out on the mechanization of pouring from the pouring ladle.

4. Improvement in the dressing machine which has made it possible to mechanize the dressing of all sections of the furnace.

5. Providing a device for uniform distribution of the steel in the ladles, which has made it possible to avoid metal losses.

6. The use of a Semilukskii brick for lining the steel-pouring ladles; this increases the service life of the ladle from 8 to 15 heats.

7. Increasing the volume of the mold from 1.3 to 1.75 $m^3$, which has considerably reduced the duration of charging.

As a result of the introduction of these and a number of other measures the department has changed over to a 7-hour working day without increasing the personnel.

Nevertheless, we still have large reserves both for the increase in steel production and for freeing the workers for other duties. In tapping these reserves an important part was played by the 1958 campaign to increase the labor productivity and the production standards.

Previously the brigade of each large open-hearth furnace consisted of the steel smelter and three assistants. During the dressing of the furnaces three assistants from the neighboring furnaces helped with the work.

Observations showed that it is more efficient to set up a regular brigade of assistants for servicing a whole block of furnaces or department as a whole. Two-thirds of the assistantsteel smelters were therefore assigned to each three furnaces. The organization of such a brigade has made it possible to reduce the duration of certain operations and has made it possible to free 16 workers. At the present time a large furnace is serviced by a steel smelter and two assistants.

On the suggestion of I. N. Kutnyi and N. F. Ogolikhin, at the casting bay on the northern part of the building a sprinkler has been set up for the slag ladles, thus freeing four workers.

On the suggestion of A. I. Kurochkin and A. F. Pisarev (gas worker and electrician) the service zones for the gas workers and electrical service personnel have been extended. This has resulted in a reduction of the number of service personnel by eight.

An important step in the further reduction of service personnel and increase in the labor productivity is mechanization in the open-hearth production. Work is being carried out on the mechanical opening of the stoppers in the steel-pouring ladles. At the present time this operation requires two men on each ladle, without considering the assistants occupied on auxiliary work. The introduction of mechanized casting will increase labor productivity at the casting bay by at least 3%.

A laborious operation is the finishing of the steel tapping hole when tapping a heat, which definitely calls for mechanization.

Work is being carried out on improving the automation of the furnaces so that the smelter does not have to control the temperatures.

It has now become essential to bring an oxygen pipe to the furnace and the casting bays. This will considerably improve the smelting and the organization of production and will also sharply increase the labor productivity in the department. It is to be hoped that the problem of supplying oxygen to the open-hearth department will be satisfactorily solved.

The level of labor productivity depends to a considerable extent on the complete use of working time in each shift. This is particularly important now that we have a 7-hour working day. Unfortunately, as well as examples of good, almost 100% use of the working time, there are some examples of considerable losses. A close examination of the working day for the steel smelter and assistant showed that only 75-80% of the working day is used efficiently. This incomplete loading is also encountered at other sections.

One way of stepping up the labor productivity is the organization of socialist competition. Socialist competition is a method of communist building, a way of stepping up creative production activity. We know that the creative initiative of the masses in socialism is directed to the adoption of better techniques and increasing the labor productivity.

Of considerable importance for the operation of the department is the widespread use of the experience of leading workers.

The best step in this direction is the organization of schools for exchange of experience right at the place of work.

In the department there are a number of unused reserves for increasing the labor productivity. The duty of every worker is to put these reserves to the service of production.

# MASTERING THE PRODUCTION OF COILED BIMETALLIC BIMETALLIC STRIP

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"Élektrostal'" Works

Translated from Metallurg, No. 1, pp. 25-27, January, 1960

Thermobimetal is a two-layer material consisting of two alloys with different coefficients of thermal expansion. The two layers are welded to each other over the whole surface of contact. The alloy with the higher coefficient of thermal expansion is called the active layer and the other is called the passive layer. Because of the different coefficients of expansion of the alloys constituting the thermobimetal, the bimetallic plate bends when it is heated. For this reason it is used as a sensing element.

The active layer of the TB-3 (GOST 5198-50) thermobimetal is N24Kh2 alloy with a thermal expansion coefficient $\geq 20 \cdot 10^{-6}$ 1/°C, and the passive layer is N36 alloy with a thermal expansion coefficient $\leq 1.5 \cdot 10^{-6}$ 1/°C. The chemical composition of the alloys constituting the TB-3 thermobimetal is shown in the table at the bottom of this page.

The alloy plates are welded under pressure during hot rolling by means of an intermediate iron layer which is electrolytically deposited beforehand on the surface of these plates. The layer of electrolytic iron serves as an intermediate material into which the atoms of the welded metal diffuse during heating prior to rolling, and it constitutes a newly formed surface without oxides and impurities; this is the main condition for satisfactory welding of the two-component plates.

The technology of the production of thermobimetal at our Works was developed* to include the melting of the active and the passive components in 5-ton arc furnaces and the subsequent casting of 500-kg ingots which are forged into sheet billets after surface conditioning. A paired billet weighs 50 kg, and is 500 mm long, 250 mm wide and 25-50 mm thick. The weight, however, of the metal pieces processed in the subsequent stages of production is not limited to this value. By using the butt-welding technique, it was possible to roll the bimetal into coils of an average weight of 250 kg.

After the forging, the cracks, fractures, scabs, and traces of the shrinkage cavity at the ends are removed by planing.

The process of iron deposition is carried out as follows: Sheet billets made of N36 and N24Kh2 alloys are secured in a clamp with their surfaces (which have to be iron-coated) on the outside as shown in Fig. 1; they are then wiped with a wet felt brush, degreased in a soda solution (150 g/liter of $Na_2CO_3$) at 50-55°C for 10-15 min, rinsed with hot water at 80-100°C and subjected to electrolytic pickling in a solution of hydrochloric acid (30-50 g/liter) at room temperature. The period of pickling depends on the quality of the sheet billets, but it should not last longer than five minutes; the current density is 5-10 amp/dm$^2$. After the pickling comes the electrolytic iron deposition in a solution of the following composition: 400 g/liter of ferrous sulphate, 150-200 g/liter of sodium chloride and not more than 4 g/liter of hydrochloric or sulfuric acid.

The electrolytic iron coating is carried out in a bath (Fig. 2). Three columns mounted on the tank are connected to a source of dc supply. The central column, on which the plate is suspended, serves as the cathode. Plates of armco-iron, which serve as anodes, are mounted on the other two columns on both sides of the sheet billet. During the iron deposition on the cathode, the current density is 10-12 amp/dm$^2$. After it is coated with iron the sheet billet is washed in hot water at 80-100°C, dried and welded along the edges with an ADS-1000-2 automatic welding machine. Used as the electrode rod is 3 mm wire of Kh18N9T steel. OSTs-45 flux is employed during the welding. The

*G. G. Kuznetsov, V. N. Zhuchin, A. A. Diomidova, B. N. Popov, V. S. Nikolskii, Yu. P. Karasev, G. N. Novikov, and B. S. Vaganov took part in this work.

| | C | Si | Mn | Ni | Cr | Fe |
|---|---|---|---|---|---|---|
| N24Kh2 | 0.25—0.35 | 0.15—0.30 | 0.30—0.60 | 22—25 | 2.0—3.0 | Remainder |
| N36 | Not > 0.05 | — | — | 35—37 | — | " |

weld prevents the electrolytic iron from oxidizing when the billet is heated in the furnace prior to being rolled.

For the prevention of the oxidation of the deposited electrolytic iron layer, it is recommended that the TB-3 alloy billets should be rolled not later than 48 hours after the welding of a set. Before being charged into the furnace, each welded plate is tested on both sides with a steeloscope, because during the heating and rolling it is necessary to know the relative positions of the N36 and the N24Kh2 layers. The plates are rolled on a three-high Lauth mill with 750/350/750 mm rolls at a speed of 1.5 m/sec.

The object of the hot rolling of the bimetal is a strong welding of the N36 and the N24Kh2 layers, and the production of an even compound plate with continuous bond showing no lamination (for an effective weld, a well heated two-plate set is subjected to reduction of the order of 30% in the first passes; at the same time the front and rear ends of the compound plate do not come apart only if the welding seam along the edges is continuous over the whole perimeter of the compound plate). When some experimental plates were welded only along the side edges a pronounced splitting apart of the front and rear ends of TB-3 plates took place.

The difficulty in rolling bimetallic plates arises from the fact that as a result of the difference in the thermal expansion coefficient of the component plates, the rolled piece tends to twist in the longitudinal direction. When the rolling of TB-3 bimetallic plates was introduced, the first plates curled into a coil and it was impossible to straighten them on the nine-roll straightening machine. An attempt to cool the plates under cast-iron slabs was not successful (when the cast-iron slabs were lifted, the bimetallic plates curled again). Straight plates were obtained when: a) the upper layer was of N36 alloy; b) the last pass during the rolling was between the middle (350 mm diameter) and the lower (750 mm diameter) rolls.

The TB-3 billets are heated in an oil-fired furnace at a temperature of 1100°C in the end zone. The billets are heated in the furnace for at least 80 minutes and their temperature on their discharge from the furnace is 1200°C. For the prevention of excessive scale formation the billets are placed with the heat-resistant component (the N24Kh2 alloy) upward and with the N36 alloy on the furnace bottom. The billets are covered on both sides with heat-resistant metal sheets. The billets are subjected to 20-30% reductions in each pass and then are cut into strips with disk knives 500-550 mm in diameter. Prior to being cut, the plates are heated to 400-600°C or are cut directly after the rolling when they are still hot. The bimetallic plates must be heated because, when cold, they bend in the transverse cross section, becoming difficult to cut into longitudinal strips. The TB-3 strips are then pickled in an acid solution. Minor defects on the strips are removed by means of electric drills.

The hot-rolled strips are welded into coils by means of resistance welding on a welding-and-coiling machine. Before welding, the strips must be tested by means of a magnet in order to determine if the two components are suitable (N36 is magnetic and N24Kh2 is nonmagnetic). Also the front and rear ends of the strips are cut off and inspected if they are well bonded. The strips are welded into coils with the N36 layer on the outside. The excess metal on the weld is milled off the top and bottom simultaneously by means of five-step cutting tools. The weld seam is then cleaned by means of an electric drill, as chips from the weld seam fall onto the surface of the strip during rolling and become embedded in the metal.

The coils are heat treated in cupola furnaces in a hydrogen atmosphere, dried to a temperature of a dew point of 60°C. The heat-treatment procedure is as follows: heating to 950°C, keeping at this temperature for 15 min. per 100 kg of the charge, cooling in hydro-

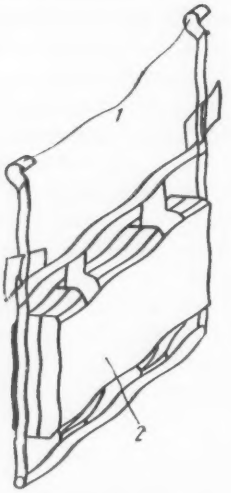


Fig. 1. Plate billets mounted in the clamp prior to iron deposition
1) copper contact hooks;
2) surface to be iron coated.

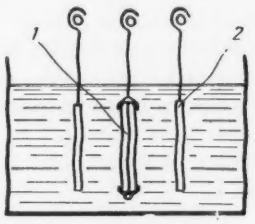


Fig. 2. Tank for electrolytic iron coating:
1) plate billet;
2) armco-iron plate.

gen under the muffle (with the cupola removed) for seven hours, and then cooling in air. Depending on their final dimensions the strips are annealed once, twice, or three times.

The strips are cold rolled on two four-high mills, one after the other. The 3.4 mm thick strip is reduced to 0.7-0.8 mm thickness on No. 1 reversible mill with working rolls 210 mm in diameter and back-up rolls 490 mm in diameter; thinner strip is rolled on No. 2 mill with working rolls 190 mm and back-up rolls 420 mm in diameter. It is essential that the rolls should be as cold as possible so that the strip does not warp. Therefore, TB-3 coils should be rolled either at the beginning of a shift when the rolls are still cold, or immediately after the roll change. To prevent overheating of the rolls, the speed of rolling in all passes should not exceed 15 m/min, and the rolls should be sprayed with a cooling emulsion.

As a result of these precautions, one obtains a strip only slightly buckled in the transverse direction, which presents no difficulties when the strip is cut with disk knives.

After the coils are cut into uniform widths their dimensions and surface condition are checked on the inspection-and-coiling machine. Samples are taken from each TB-3 coil for the following tests: sensitivity coefficient, electric resistance, welded bond strength, and the uniformity in the thickness of layers.

The TB-3 strip is tested, packed and supplied to conform to GOST 5198-50.

* * *

## PRESENT METHODS OF TIN PLATE PRODUCTION

A. I. Vitkin

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Modern methods of tin plate production constitute a high-speed process carried out on continuous machines arranged consecutively, in trains. Continuous pickling trains, rolling, and degreasing trains have been in use for a relatively long time and are reliable in operation.

For a long time, however, no solution could be found to the process and design problems of introducing continuous annealing and pickling operations. It is only in the last decade that the annealing of coiled tin plate in cupola furnaces has been more and more extensively replaced by continuous annealing in horizontal and tower (vertical) heating trains. In the continuous process, the total time for annealing and cooling of coils has been reduced from 40 hr to 80-140 sec., the heat treatment regime has been improved significantly and the strip treated uniformly over its length and cross section. In some recent machines, the heating of the strip takes only 6-8 sec while the strip moves at a speed of 10-12 m/sec. With such a continuous line, one can anneal up to 250,000 tons of strip annually. With the introduction of the continuous process, the whole scheme of operation is simplified, since the degreasing and heat treatment operations are carried out simultaneously.

Only the hot dip tinning process remains still unsatisfactory, and so far no practical method of continuous tinning has been found. At the "Zaporozhstal'" Works in the Soviet Union and in East Germany the steel strips are hot tinned with a relatively heavy coating approximately 3 μ thick at a low speed (up to 3-5 m/min) of strip movement. The bulk of world tin plate production is done by machines employing sheet-by-sheet tinning at a speed of 15 m/min. However, as the volume of production increases, this method is becoming cumbersome and inefficient, starting with cutting of the strips into sheets, and finishing with packing the sheets into packets.

The transition to a continuous, fast tinning process has become possible only in connection with the introduction of electrolytic tinning.

In 1942-43, in the USA, 19 electrolytic trains of 2 million tons capacity were put into operation, and at the same time all electrolytes studied so far – alkalies, sulfates, and halides – were used. Since then, the production of tin plate has substantially increased throughout the world; the annual production in 1941 was 3 million tons and in 1959, 8 million tons. The increase in the total production of tin plate has taken place exclusively on account of the production of electrolytic tin plate (up to 5 million tons annually.) The output of hot-dipped tin plate has recently remained on the same level, and even shows a downward trend (2.5 million tons annually.) In 1958, electrolytic tin plate production in the USA constituted more than 90% of the total tin plate production. Because of the increase in the percentage of the new type of tin plate, the consumption of tin in absolute units in 1958 remained the same as in 1941 (approximately 70,000 tons), in spite of the fact that the output of tin plate in that time increased by a factor of

Comparison of Electrolytic and Hot-Dip Tinning

| Characteristics | Electrolytic process | Hot-dip process |
|---|---|---|
| Thickness of coating, microns | 0.5-1.5 | 2.0-5.0 |
| Deviations in the thickness of coating per one $m^2$, % | 10 | 30 |
| Coefficient of tin utilization | 0.95 | 0.80-0.85 |
| Yield of first grade product, % | 95 | 75-90 |
| Speed of tin plate movement, m/sec | 5-12 | 0.1-0.25 |
| Output of the machine, thousand tons/year | 150-250 | 10-15 |

2.5. By 1959, there were approximately 65 continuous electrolytic tinning machines in the world of which only 5-7 machines used halide electrolytes; 14 machines used alkalies, and the remaining ones used sulfate electrolytes.

The advantages of the new tinning process over hot-dip tinning are shown in the Table.

In addition, with the electrolytic method of tinning, it becomes possible to obtain a so-called differential coating in which the strip is covered on one side with a coat 0.4-0.5 $\mu$ thick (the external side of the can), and on the other side with a coat 1.5 $\mu$ thick (the internal surface of the can). In this way a substantial saving in tin consumption is achieved since the average thickness of tin coating remains below 1 $\mu$ while the internal surfaces of the tins have satisfactory protecting layers.

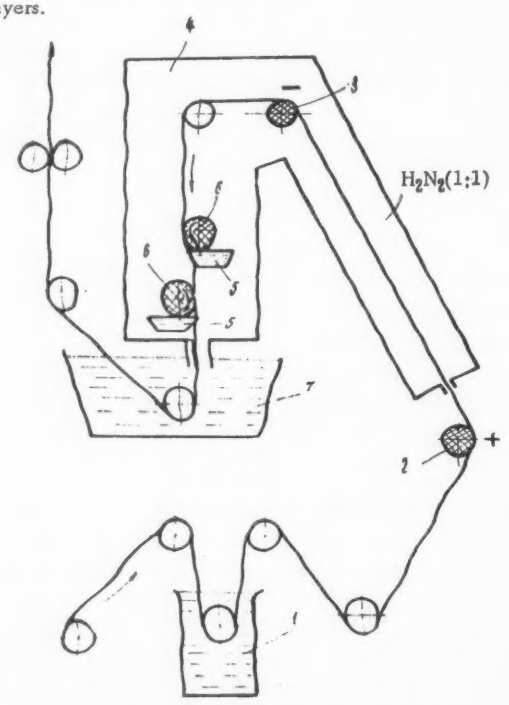


Fig. 1. Diagram showing the method of tinning steel strip by means of rolls; 1) degreasing tank; 2, 3) current-removing rolls; 4) chamber with gas atmosphere; 5) vessels with liquid tin; 6) rolls for coating the strip with tin; 7) water seal.

Recently, new trends in the development of the continuous hot-dip tinning process have been noted. In England, a method of tinning by means of a special roller (roller coating, Fig. 1) in an active gas medium is being developed. In the Soviet Union, the TsNIIChM is developing several methods for the rapid coating of steel strips with tin; of these methods, it is worth mentioning tinning in a high-voltage electric field (Fig. 2) and the electrolytic deposition of tin in molten salts (Fig. 3). During electrolysis in molten salts, the thickness of coating can be controlled within the wide range of 1.5 to 5.0 $\mu$. The operating conditions ($D_c \sim 200$-300 amp/$dm^2$; $\eta_C \sim 100\%$, time of tinning $\sim$ 2 sec) permit the strip to move at a high speed. The tin layer obtained on one side of the strip has a high luster and high resistance to corrosion.

In recent years, the production of painted black plate, developed in Germany a few years before the Second World War, has increased extensively. Initially,

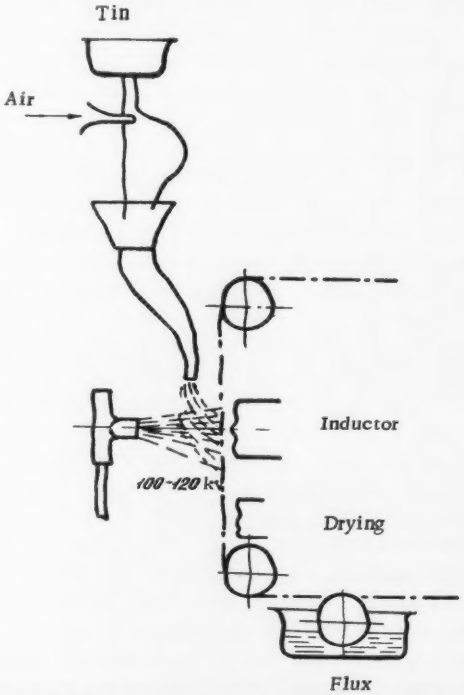


Fig. 2. Diagram illustrating the tinning process in a high-voltage electric field.

the painted plate was produced because of economic circumstances. As the technique has been mastered, the processes of preparing the plate surface for painting have been improved and the quality of the painted plate has improved continuously.

Using the accumulated experience, the TsNIIChM and the TsNIIKOP have been working on the production of painted plate in the Soviet Union since 1954. In the course of recent years, small commercial consignments of painted plate have been produced; cans made of this plate have been used for various canned foodstuffs, such as fruits, meat, fish, vegetables, etc. Experiments showed that painted plate is quite satisfactory for weak acid media and also for very corrosive fish products (herrings, and cod in oil and tomato), as well as for fruits (blackcurrents, cherries, etc.). So far, a safe time period for storing foodstuffs in those cans is limited to 1-2 years.

A significant difficulty in the development of the production of painted plate has been the lack of high

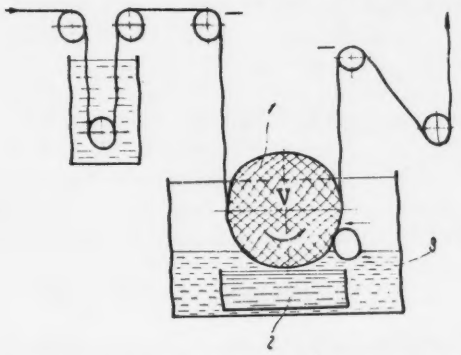


Fig. 3. Diagram showing electrolytic tin plating in molten salts: 1) drum; 2) liquid tin anode; 3) melted salts (300°C).

speed processes for painting and drying. Roller painting and convective drying in long furnaces for 7-20 min do not permit the speed of the strip to exceed 3-10 m/min.

In this connection the TsNIIChM investigated fast processes of paint application by means of deposition in a high-voltage electric field and induction drying by high-frequency current (Fig. 4). The adoption of rapid methods of application and drying of paint has now become an extremely important problem for the national economy.

Among the new types of coating one should mention the combination of a thin steel base with plastic coating. In some countries, plants for producing plastic-coated steel strip are already in operation. Extensive investigations in this field are under way in England, West Germany, and other countries.

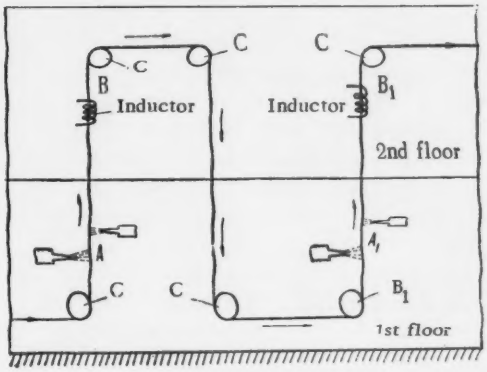


Fig. 4. Diagram showing the deposition and drying of a paint coat on a steel strip: A and $A_1$) the application of the first and second paint coats respectively in a high-voltage electric field (100-120 kv); B and $B_1$) induction drying of the first and second coats respectively; C) rolls.

# METHODS OF IMPROVING THE EFFICIENCY OF SECTION MILLS

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Steel Rolling Shop of the "Dneprospetsstal'" Works
Translated from Metallurg, No. 1, pp. 30-34, January, 1960

A substantial increase in rolled steel production during the current Seven-year Plan is to be achieved by modification and modernization of the existing rolling mills.

In connection with carrying out these tasks, it is interesting to consider the work on the improvement of equipment and technique done at the "Dneprospetsstal" Works, as a result of which it has become possible over a period of several years to increase the output of rolled steel, improve operating efficiency, reduce the percentage of defective product, and reduce the cost per ton of rolled steel.

The Rolling Shop is comprised of four mills, one 825 roughing mill, and three section mills – 550, 325, and 280 – designed for rolling high-alloy steel and alloys.

The rolling mills, in particular the 550 and 325 mills, at the time they were put into operation (1952-1953), were not extensively mechanized and were not suitable for rolling high-alloy steel and alloys. The mill equipment has now been mechanized and automated with the object of increasing the output.

The heating facilities of the rolling mills have been modernized over a period of several years, and have been adapted for handling high-alloy steels. The best results were achieved when the bottoms in the soaking pit cells were changed to chrome magnesite. It then became possible to dispense with the coke bed on the furnace bottom, to effect some savings in coke fines and to improve the heating of the lower part of ingots, significantly. The walls of the cells, too, were redesigned. Rows of firebricks were incorporated in the silica brickwork, and as a result, the durability of the cell walls has increased and the period between repairs has doubled.

A considerable amount of work has been carried out on the reheating furnaces of the section mills in order to ensure a higher efficiency in the heating of the steel; the supporting partition walls in the heating zone have been removed and so the heating from below has improved; the control of the burners and of the pressure in the furnace has been changed from hydraulic to electronic; the design of the runners has been changed (the metallic runners have been replaced by chrome-magnesite runners). Some of the modifications carried out are of fundamental significance for the design of new reheating furnaces in rolling mills. In particular, at one of the two continuous furnaces at the 325 mill, the heated steel was discharged through the end wall of the furnace (the other furnace had side discharge doors).

The two-zone furnace with the end discharge of steel was found unsuitable for heating high-alloy steel billets because of a substantial leakage of the air into the furnace through the end wall. During the intervals specified by the operating instructions for heating R-18, Kh12, 3Kh2V8, and other high-alloy steels, the steel was not heated up, but, on the contrary, was cooled down, which resulted in fractures of the rolls.

When this furnace was modified and provided with side discharge facilities (instead of end discharge), the output of the mill increased and the fracture of rolls ceased.

The mechanization of manual operations at the roughing stands, where high-alloy steels are rolled, involves some difficulties because of the various lengths and cross sections of the billets and also because of the variation in the speed of rolls depending on the steel rolled. This problem has been solved at the 325 mill in the following way.

A new design of tilting plates, which were installed at the front end of the stand and which made it possible to roll billets of various lengths and cross sections, was developed. The horizontal portion of the plate is equipped with rollers which prevent the steel from being scratched and also ensure an easy movement of the the steel along the plate. In this way, the manual labor at the front end of the stand has been completely eliminated. At the rear end of the stand, the lifting-and-tilting table has been provided with a manipulator by means of which the operator can transfer the stock from one pass to another. In addition the lifting-and-tilting table has been modified with the object of increasing the speed of lifting. A new roll design for the roughing stand was developed in which the rolled piece is turned only at the front end of the stand by means of tilting plates (except in one pass in which the rolled piece is turned at the rear end of the stand).

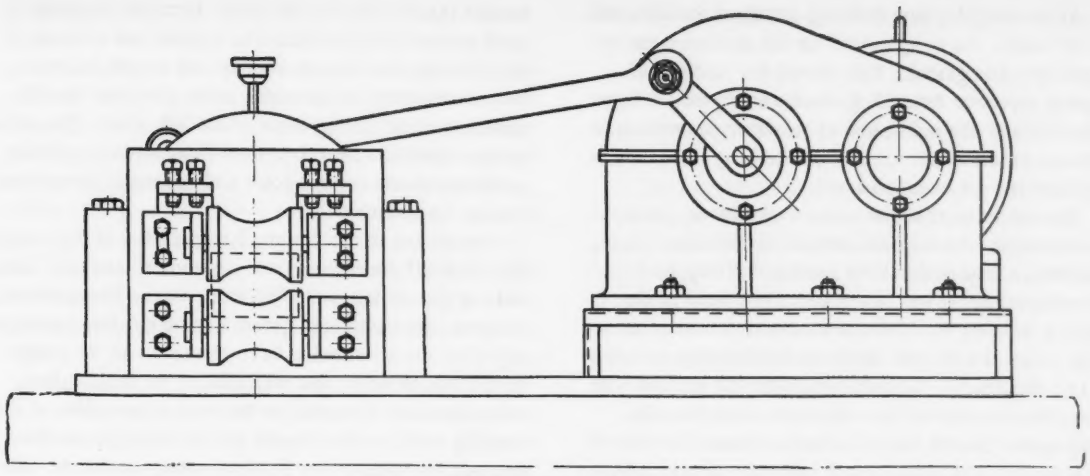

Fig. 1. Turning box.

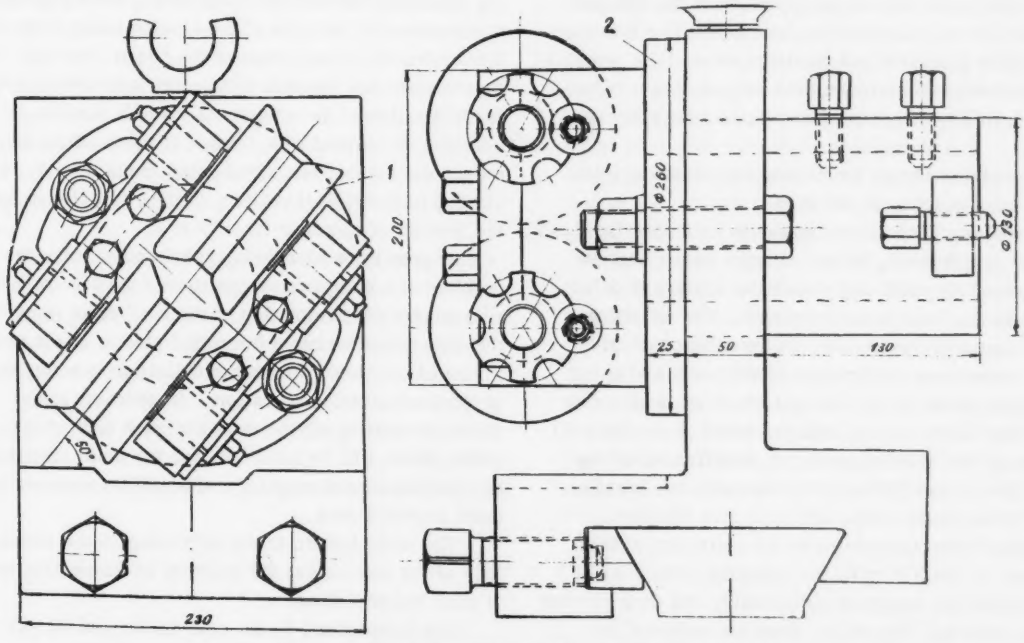


Fig. 2. Delivery turning guide: 1) roller; 2) head.

The problem of transferring the stock to the finishing train has been solved in a new way at the 325 and 280 mills. Previously, transfers were used for this purpose at both mills. Rolled pieces at the 280 mill were turned by means of a helical guide, and at the 325 mill by hand. It was found by experience that this arrangement was quite unsuitable for rolling high-alloy steels because the quality of the surface of the rolled piece was not ensured (an indentation line is formed) and the rolled piece frequently jammed between the rollers of the transfers.

On the suggestion of innovators at the shop, the transfer of the stock to the finishing train was arranged as follows. The roughing and the finishing trains were connected by a power-driven roller table on which a tilting box with interchangeable grooved rolls (Fig. 1) was mounted and was actuated automatically by a lever switch which could move along the roller table. In this way, the time of tilting is controlled. The tilting box is quite satisfactory in operation if the rolled piece is in the two trains of the mill.

With this modification, the percentage of defective product was reduced, the rate of rolling increased and, in addition, it became possible to roll square sections of high-speed steel without intermediate reheating at the 325 mill.

At the roughing and finishing stands of the 550, 325, and 280 mills, the entry guides for all sections were replaced by roller guides. This solved the problem of adopting repeaters for rolling round and square sections at the 325 and 280 mills, and at present repeaters are in operation on all stands except the finishing stands where they have not yet been mastered.

The use of steel or even cast-iron delivery guides does not ensure the required surface of the rolled piece. Therefore, a new design for a turning delivery guide with rollers (Fig. 2) was developed. The head of the guide is secured with bolts to a support, mounted on a block. A steel tube (not shown on the drawing) is inserted into the head of the delivery guide and secured with bolts; the other end of the tube is set near the rolls. Owing to the slots in the guide body, where it is secured to the support, the roller can be rotated relative to the axis of steel rolling and set for a required turning angle. Similar guides are used on all repeaters of the 280 and 325 mills for the transfer of oval sections. The introduction of these guides has substantially reduced the quantity of products with defective surface and, in effect, it has made the rolling of intermediate sections for alloy steel possible.

A special workshop for making and repairing roller guides has been set up at the shop.

In addition to the above measures for improving the equipment at the mill, several changes which improve the output of the mills and reduce the amount of defective production have been introduced. The following changes could be mentioned: the installation of drives for the screw-down mechanisms of the lower and upper rolls on the stands of the 550 mill, the introduction of a turning box in front of the finishing stand of the 550 mill for entering the finishing oval, the modification of the rolling field of the 550 and 325 mills with the installation of driving roller tables and pull-over transfers.

Owing to the automation of the main part of the equipment at the 325 mill, the operating efficiency of the personnel has improved considerably and their number has been reduced. The pulse from the cabin of the grab crane effects the following operations automatically: the dispatch of the ingot car, the double deceleration of the ingot car, the lowering of the cradle with the ingot on the receiving roller table, the starting of the receiving roller table, the transfer and stopping of the ingot, the turning and delivery of the ingot to the working roller tables, the lifting of the cradle without the ingot and the dispatch of the ingot car to the required group of soaking pits.

Previously, the various mechanisms of the 325 mill were controlled from five control points by six operators per shift. As a result of the work carried out, the following operations have been automated: the delivery of the billet from the furnace (controlled by a pulse from the pusher to the roller table of the roughing stand); the transfer (and turning) of the billet from the roughing stand to the finishing train; the control and start-up of the pull-over transfers in front of and behind the mill; the control of the roller tables of the IVth and the Vth stand and of the lifting table of the Vth stand. The automation which has been introduced has made it possible to eliminate one control point and has made six operators free for other duties.

According to the design, the operation of the coilers, the kick-off mechanism to the cooler, and the rack table of the cooler at the 280 mill was to be automatic. However, the automatic system can be put into operation only after the scheme has been changed and the equipment modernized by the personnel of the shop. Later, automation was extended to the front roller tables of the roughing train, to the transfer of the rolled pieces from the roughing train to the finishing train, and to the control and start-up of the following mechanisms: the driving rollers in front of the flying shears, the flying shears themselves, the switches of the feeding roller tables to the cooler, the roller tables of the cooler, the kick-off mechanism, and the rack table. The automation and modernization of the equipment made it possible to combine the control of a number of mechanisms and to reduce the number of control points from nine, as envisaged in the original project, to five, and also to reduce the number of operators from 32 to 8.

At present, work is being continued to solve the problem of a complete automation of the 280 mill: This will require the automation of the breakdown stand, of the dimension control of hot-rolled pieces, of the removal of hot sections from the coilers and cooler, and of the identification operations. In addition, rotary shears for cutting off the front and back ends of the rolled pieces will be installed, and the main motors of the breakdown and roughing trains will be replaced by more powerful ones.

The main feature in the improving of the technology of the process was the increase in the heating rate of steel before rolling.

The temperature in the cells of the soaking pits was increased from 700 to 1000°C for heating cold-charged stainless steel. No limitation was imposed with regard to the rate of raising the temperature of the cell to the required value when heating hot-charged ball-bearing steel.

Recently, new regimes for heating ingots in soaking pits involving so called "step-heating" were developed. The following are the essential features of the new regimes. Previously, the temperature in the cell was raised to the required level, and then the steel was soaked with the object of bringing the temperature of the ingot to the temperature of the cell. This soaking process took a long time. According to the new instructions, the cell is heated to a higher temperature until the surface of the ingot attains the pre-set temperature. At that time, the

gas is rapidly cut off, the temperature of the cell is reduced to the predetermined value, and the soaking process, during which the temperature of the surface and the bulk of the ingot becomes uniform, is carried out. Of course, with the new method, the soaking period is shorter than it was previously, since at the beginning of the period the surface of the ingot is already at the required temperature. Owing to this method, the time for heating the ingot is considerably reduced (for instance, for stainless steel the time was reduced by 30%, and for ball-bearing steels by 15%; the average throughput capacity of the cells for all the products increased by 12-13%).

A significant step toward mastering the rolling of high-speed and some other high-alloy tool steels was the introduction of a method of heating billets for section mills in continuous furnaces on skids with a subsequent equalization of the temperature on the furnace bottom. The introduction of this method of heating in combination with high-speed rolling with the use of cast-iron rolls and the introduction of repeaters made it possible to dispense with the reheating during the rolling of very small sections from square billets of 100 mm side. As a result of this, the reheating furnace installed according to the original design between the roughing and the primary stands at the 280 mill is not used.

These facts should be taken into account in future projects. In addition, owing to the introduction of the above methods, the percentage of defective products due to fractures occurring during the rolling of square sections from high-speed steel has been reduced.

Extensive work has been carried out by the Rolling Shop jointly with the Central Works Laboratory regarding the decarbonization of steel. In 1955, the defective products at the 280 mill caused by decarbonization constituted 68.6 tons, but in 1958 this figure was reduced to 2.2 tons.

A method which is new in principle for reducing the impurities in the $\alpha$-phase of stainless steels by means of heat treatment after rolling has been developed at our shop.

The development of the roll design of the breakdown stands was of great significance. The guiding principle in this work was the attainment of the maximum stability of the steel in the grooves, the possibility of rolling all types of steel with the same set of passes on the rolls and the attainment of the greatest possible reductions compatible with the limiting angles of bite (the draft in the oval passes reaches up to 1.70).

Recently, in connection with the supply of semi-finished material for section steel, the roll design for rolling circular sections has been perfected. In particular, edge passes have been adopted instead of pre-finishing and roughing square passes. At the same time, the number of passes has not been increased. The adoption of this pass arrangement has made it possible to reduce the percentage of defective product which was due to surface defects and it has made the rolling of high-speed steel with the use of repeaters easier.

The mills of our shop have introduced the production of several reduced weight steel sections for the machine-building industry. Special "U"-shaped sections of stainless steel are rolled, and the production of leaf springs with parabolic edges, and of plough shares, from Kh12F1 steel has been mastered.

All the above steps aimed at an improvement of the main and auxiliary equipment have made it possible for the mills to introduce the rolling of high-alloy steels and alloys, to increase production by 41.8% and operating efficiency by 56.1% (compared with 1953), and to reduce the percentage of defective product to 0.19%.

* * *

# IMPROVING THE SOAKING PITS OF BLOOMING MILLS

S. D. Gekhtman

Group Leader of the "Tsentroenergochermet"

Translated from Metallurg, No. 1, pp. 34-37, January, 1960

At present, approximately half the blooming mills which are in operation have multicell regenerative pits, 2.2 × 4.5 m, with four pits in a group having a floor area capable of accomodating 6-8 ingots. Gas and air are heated in the regenerators of these soaking pits. A system of electrically operated valves has been designed for changing the direction of the flame. The charge and the discharge of ingots and the lifting of covers are completely mechanized.

In the course of operation these pits have been considerably improved. The throughput capacity of a group of pits (four cells) at leading steel works in the Soviet Union has increased from 150 to 270-370 thousand tons per year. Now it has become possible to heat the pits

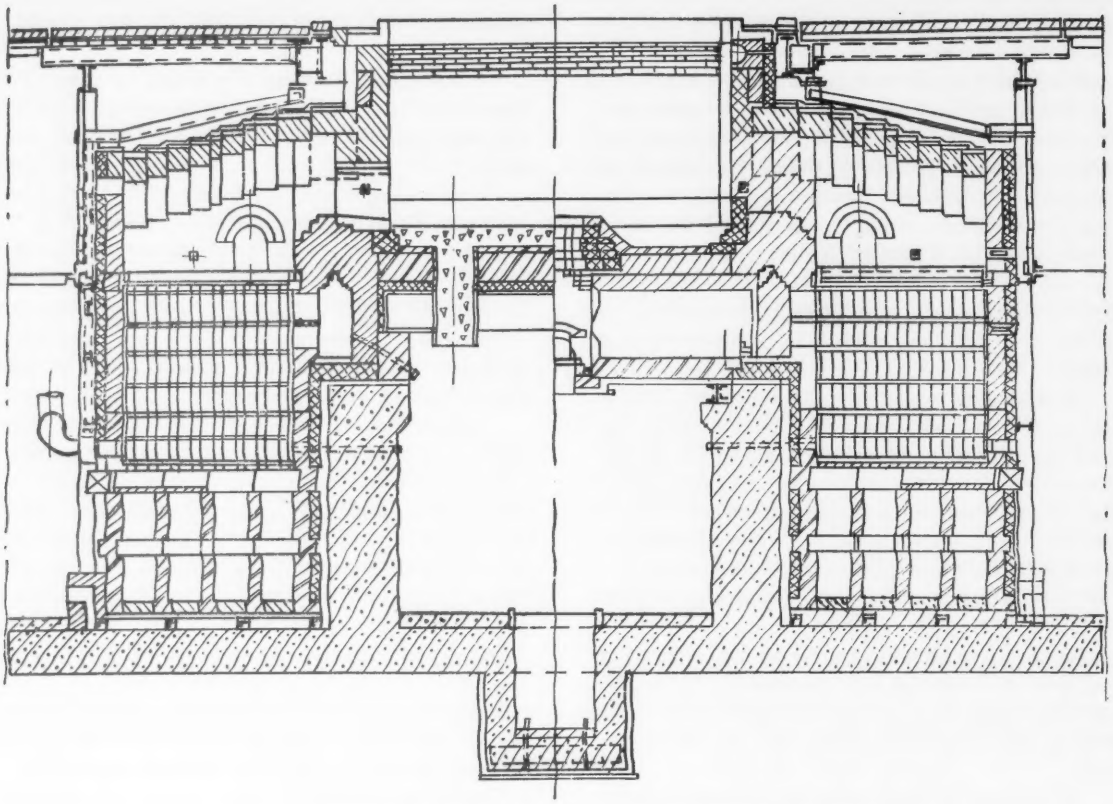

Fig. 1. Recuperative soaking pit fired from the center of the bottom.

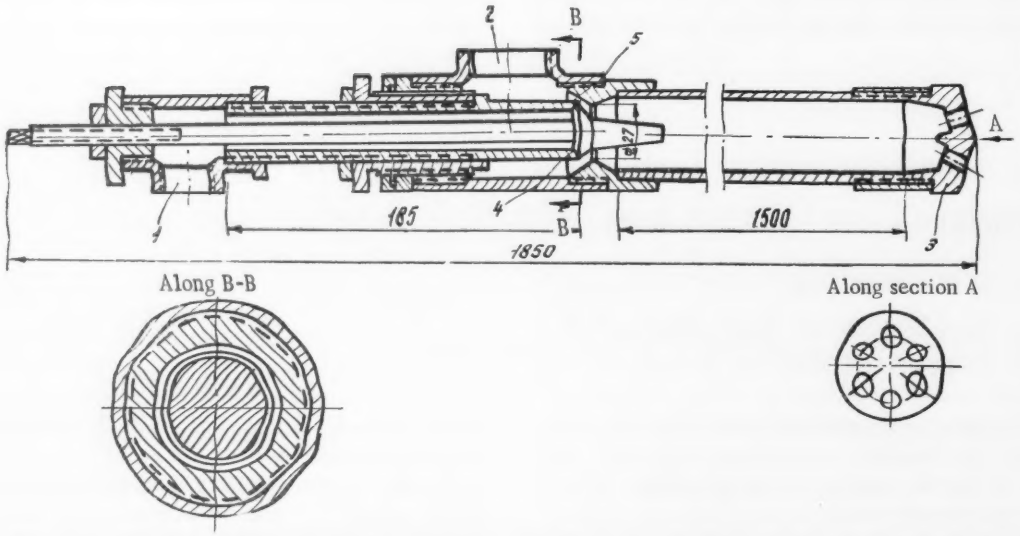


Fig. 2. Multistream burner for soaking pits: 1) fuel oil inlet; 2) compressed air inlet; 3) burner tip; 4) orifices for oil outlet (8 openings in a circle); 5) gap for compressed air outlet.

with pure blast-furnace gas, and the liquid removal of the slag from pits of this type was introduced here for the first time in the world. The specific consumption of conventional fuel in the pits is 3.4-4.0% when the hot-charged ingots (785-800°C) constitute 93-97% of the total quantity of ingots heated.

A characteristic feature of the heat balance for this type of pit is a high enthalpy of the gas entering the working space of the pits, owing to the heating of the gas to 1000°C in the regenerators.

The regenerative soaking pits have, however, several shortcomings:

a) Some ingots are not heated uniformly, so that the sides which face the regenerators melt, and the ingots located in the center of the working space are heated much more slowly;

b) Inadequate arrangements for shrinkage resulting in local fusion of ingots; it is impossible to obtain complete combustion in the working space and to use gases of high calorific value (e.g., natural gas) for heating the pits;

c) There are a large number of valve-changing attachements and separate mechanisms for cover lifting which require considerable man power for pit operation.

All this makes the operation and the automation of pits rather difficult; therefore, in the post-war years the construction of better, automated recuperative soaking-pits fired from the center of the furnace bottom (Fig. 1) was initiated at metallurgical establishments.

The burner located in the center of the furnace bottom consists of a circular brick duct for the hot-air supply and a heat-resistant steel tube with a gas-feed nozzle. The air is heated to 750°C in ceramic recuperators but the gas is not preheated. The rising combustion products are reflected from the roof, descend and flow around the ingots and pass to the recuperators. The gas used for firing in these pits has a calorific value of 1300-1600 kcal/$m^3$; the pit can accommodate 10-16 ingots of 6-7 tons or 18-20 ingots of 3-4 tons.

Recuperative soaking pits with a central burner have several advantages over regenerative pits:

1. A minimum loss in burning and a minimum percentage of defective material during heating, which is quite essential for special steels which have to conform to very rigorous requirements.

2. Since it is easy to maintain a predetermined heating regime, the automation of the control of soaking pits becomes relatively simple and the work of the operating personnel is facilitated.

3. A complete combustion of fuel takes place in the working space of the pit owing to the improved design of the burners. The excess air coefficient is approximately 1.

4. Gases of a high calorific value can be used.

However, several disadvantages have become apparent during the operation of the recuperative soaking pits:

1. Ingots are heated at a lower rate than in the regenerative pits.

2. There are large air losses due to leakage in the ceramic recuperators.

3. Recuperative pits are not suitable for the removal of slag in the liquid state; they have to be heated with mixed coke-oven and blast-furnace gas of 1300-1600 kcal/$m^3$ calorific value; when fuel oil is used, the service life of the furnace cover is short (1.5-2 months).

As a result of several years of joint effort of the Stal'proekt and the Tsentroénergochermet, the main shortcomings have been eliminated. The heating regime of the pits has been changed, and in particular the heating temperature has been increased, the initial air losses in ceramic recuperators have been reduced from 30-40% to 20-25% by lining the recuperator walls with steel plate, reducing the pressure loss of the air stream, improving the quality of the brickwork and establishing operating conditions which exclude rapid cooling of the recuperators. The service life of the recuperators has been increased from 6-12 months to 25-30 months. A method of producing liquid slag in the pits by means of spreading fluxing additions on the furnace bottom (boiler slag, a mixture of fine coke with sand and lime, etc.) has been developed and the removal of slag in the liquid state has been adopted. At the "Azovstal'" Works alone these improvements resulted in a saving of 3,000 tons of steel and 16,000 tons of coke, and an increase in the throughput of the pits by 8% per year.

For oil firing of soaking pits (at the Zakavkaz and the Azerbaidzhan Works) the Tsentroénergochermet developed and introduced a multistream burner (Fig. 2) which improves the combustion process and extends the service life of the pit covers substantially.

As a result of the above measures and of a reduction in the duration of auxiliary operations (cleaning and fettling the pit bottom, charging and delivering the ingots) the speed of the ingots has been increased considerably and the operation of the pits has become more economical. The output of a group of pits (two cells) of one of the best works in the Soviet Union is close to 265,000 tons; specific fuel consumption amounts to 3.9-4.1% when 85% of ingots are charged hot.

Characteristic features of the heat balance of the recuperative pits are: no preheat of the gas, no heat losses due to leakage in the recuperator, and no high heat losses through the pit walls because of the relatively large dimensions of the pits. Nevertheless, owing to a better utilization of heat in the working space, recuperative pits are more economical in operation than regenerative ones.

Recently, the Stal'proekt has modernized the design of recuperative soaking pits with a central burner. Pits

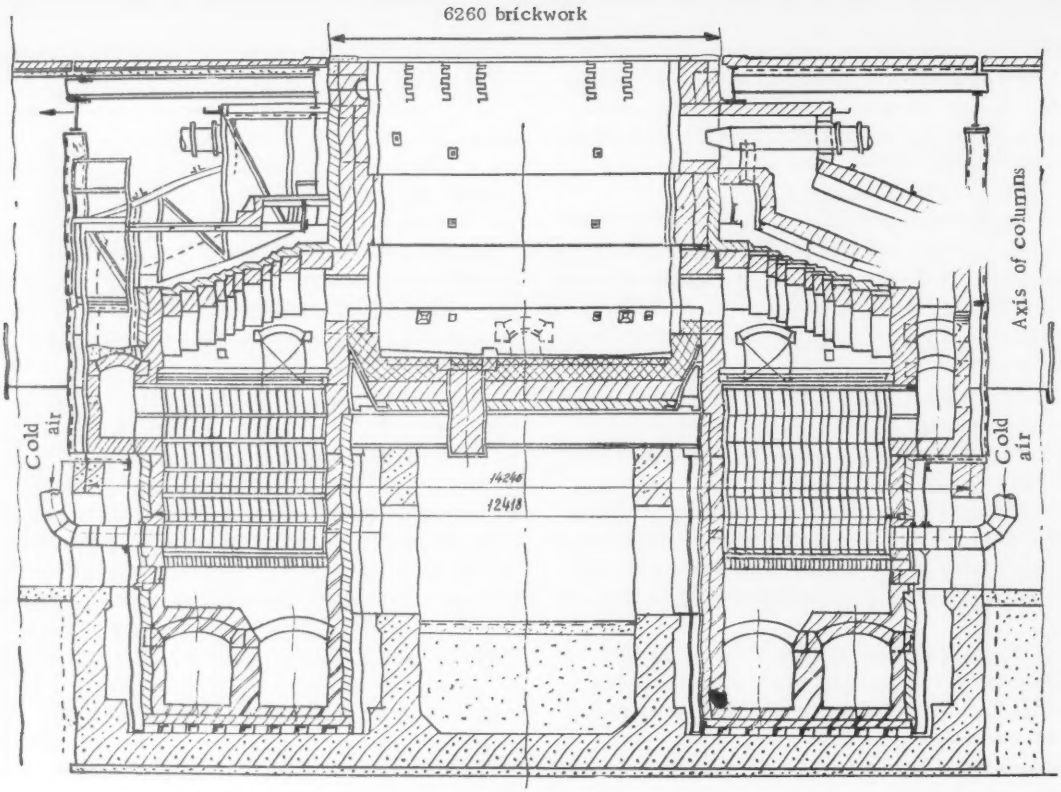


Fig. 3. Recuperative soaking pit with two top-fired burners.

which have a working space of 5000 x 4600 x 3100 mm will have metallic recuperators for gas heating with 140 $m^2$ heating surface. Gas is to be heated to 270-300°C.

The size of ceramic recuperators for air preheating is increased by a factor of 1.36 and, therefore, the temperature of the air increases from 750 to 850-900°C. The pits have been designed for liquid slag removal and, at the same time, provided with coolers for the prevention of the flow of liquid slag into the hot-air duct. The duct is covered with plate iron.

Experiments carried out by the "Azovstal'" Works, the Tsentroenergochermet, and the Stal'proekt, have shown that the output of modernized recuperative pits is 5-10% higher, and the specific fuel consumption 10-15% lower than in similar nonmodernized pits.

In recent years, the Stal'proekt has developed a number of designs for recuperative soaking pits which are heated from above. Since the burners in these pits are mounted in the top part of the walls, the whole bottom of the furnace can be utilized for ingots (big-end-down ingots).

An experimental group of pits with two top burners (Fig. 3) is at present in operation at the "Azovstal'" Works. Pits with one top burner and a single-section ceramic recuperator from which the hot air is taken out by an exhaust fan are being built at the "Krasnyi Oktyabr'" Works.

The use of the exhaust fan instead of a pressure fan makes it possible to eliminate air losses from ceramic recuperators. The pits will be fired with natural gas and the heating process of the ingots will be completely automated.

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# EXPERIENCE ON THE OPERATION OF A ROLLING MILL WITH FLUID-FRICTION BEARINGS

**D. P. Galkin and A. E. Pratusevich**

Magnitogorsk Metallurgical Combine
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Until 1959, the back-up rolls of the finishing stands of the 1450 continuous thin-plate four-high mill at our Combine worked on four-row conical roller bearings of the TsKB-845 type.

The roller bearings of the back-up rolls of the stands in the finishing group ensured neither continuous mill operation nor the required quality of the product.

The necks of the back-up roll had a diameter of 520 mm (corresponding to the dimensions of the TsKB-845 bearings) and, because of their inadequate bending strength, they frequently broke, thus causing stoppages of the mill. In addition, the necks wore out rapidly and unevenly because it was difficult to distribute thick lubricant over their whole length and this resulted in uneven thickness, buckling and warping of sheets in excess of the specified tolerances. When the worn necks of the back-up rolls were rebuilt with welded-on hard alloys, internal stresses and microcracks appeared in the transition section between the neck and the barrel of the roll because of the difficulty in heating the barrel and, therefore, fractures of the necks of the back-up rolls became more frequent.

The wear of the contact surfaces of the external racers and the chocks of the back-up rolls also had a negative effect on the quality of the sheets rolled.

Uneven and excessive wear of the necks of the back-up rolls caused high axial stresses because of the deviation from the parallel alignment of the back-up and working rolls. The axial stresses resulted either in the "forcing out" of the working rolls from the stand, damage to the bearings of the working rolls and the fracture of the connection plate of the working rolls, or in a displacement of the rolls toward the stand drive, involving frequent breakdowns of the thrust section of the pinion bearings or even axial displacement of the pinion housing.

The wear of the necks of the back-up rolls caused uneven passage of the rolled piece through the stands of the finishing group and, therefore, the stock frequently jammed.

These difficulties in the operation of the mill and the existing experience on the operation of other plate mills formed the basis for converting the back-up roll of the finishing group of the thin-plate mill to 800 x 480 mm liquid-friction bearings. The neck of the back-up roll has a conical shape; an increase in its diameter from 520 to 710 mm in the critical cross section increased its bending stress by a factor of 2.5. Liquid lubricant (bright stock) used for liquid-friction bearings is fed under a pressure of 2-2.5 atm.

In spite of the obvious improvements in the operation of finishing stands on changing to the liquid-friction bearings, for a long time considerable difficulties were experienced in obtaining good quality steel plate (the plates were uneven and with crown). After 8-10 hr of operation with new back-up rolls, a rapid deterioration in the shape of the plate was observed in connection with the wear of the roll barrel. It became necessary to increase the convexity of the upper working roll of the last stand in the finishing group. However, the increase in the convexity, even to 0.5 mm, did not give the results expected, since the barrel of the back-up roll was then subject to even heavier wear. The failure to obtain a good quality plate gave rise to doubts whether the choice of material for the back-up rolls (80KhN3V forged steel, Shore hardness of the roll body, up to 56) was correct and if it was right to use liquid-friction bearings for the last stands of the finishing group.

During subsequent operation of the back-up rolls of the finishing group on liquid-friction bearings, it was established that the excessive wear of the back-up roll barrel was due to the heating of the barrel edges adjoining the massive neck and to the hot bearing (the temperature of the bearing reaches 60°C). It was found that the rolls were subject to "thermal" wear and this resulted in a concave shape of the roll barrel. The deformation of the barrel of the back-up roll, caused also by an uneven temperature of the necks (it is difficult in practice to obtain the same temperature of the roll necks), resulted in pronounced crown on one side of the rolled plate.

The personnel of the mill carried out some measures aimed at the elimination of the thermal wear of the back-up roll-barrel.

Special headers for cooling the ends of the barrel of the upper back-up roll over 200 mm long sections

were introduced (the barrel of the lower back-up roll is amply cooled with water sprayed on the barrels of the working rolls).

An increase in the temperature of the barrel of the back-up roll by 10°C corresponded to an increase in the roll diameter by 0.1 mm (the diameter of the roll barrel is 1050-1070 mm). It was found in practice that in the first 8-10 hr of operation, a new back-up roll suffered thermal wear of an order of 0.2 mm which completely disappeared after the roll was removed from the stand and cooled for 24 hr.

With the object of compensating for thermal wear and the usual abrasive wear, we began to make the new back-up rolls convex (a convexity of 0.3 mm for the upper rolls and 0.2 mm for the lower rolls). In this way, it became possible to reduce the number of intermediate roll changes necessitated by roll barrel wear and to improve the quality of the rolled sheets substantially.

Thus, experience on the operation of the finishing stands of the thin-plate mill showed that the application of liquid-friction bearings for the back-up rolls permits a rapid reduction in the number of fractures of back-up rolls, and improvement in the quality of the sheets produced, and a reduction in the axial load of the working rolls.

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# THE ELIMINATION OF TRANSVERSE CRACKS DURING THE HEATING OF BALL-BEARING STEEL

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A. K. Serov Metallurgical Combine

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Defective products due to transverse cracks constituted a substantial percentage (up to 6.5%, and for some heats up to 20-25%) during the rolling of ball-bearing steel ingots cooled after casting and then reheated in soaking pits at the 850 heavy-section mill of the A. K. Serov Combine. The formation of transverse cracks was caused by stresses resulting from cooling the ingots as well as during the initial stage of heating in the pits where the temperature at the time when ingots were charged was within 300-450°C.

The work carried out by the Central Works Laboratory at our Combine has established that a preliminary tempering of cold ingots at 680°C, in combination with heating of ingots in the pits with cells at a temperature of not more than 200°C at the time of charging, makes it possible to reduce defective production due to cracks from 6.5 to 0.1-0.3%.

# THE CONFERENCE ON SAFETY AT SINTERING PLANTS

Translated from Metallurg, No. 1, p. 42,
January, 1960

A conference on the prevention of dust and other industrial hazards, and also on safety at sintering plants, was held in Krivoi Rog from March 27 to 28, 1959. Participating were 130 representatives from 48 industrial establishments and design and research institutes. The conference was arranged on the initiative of the Central Committee of Metallurgical Worker' Trade Union.

After the introductory speech by A. P. Rudnev, member of the Presidium of the Central Committee of the Union, a number of papers and reports were read and discussed.

N. V. Sinebryukhov (VNIIOchermet) made some recommendations regarding safety technique at sintering plants. Thus, for instance, a modification of the bins and the introduction of electrovibrators will make it possible to eliminate rabbling the materials in the bins by hand. Skidding of the conveyor belts can be prevented by lining the conveyor rollers with old belts and by appropriate maintenance of the stretching equipment. The author stressed the need for developing a method of handling lime without dust emission.

S. P. Chernavin (Mekhanobrchermet) reported an experimental unit for compacting the concentrate and roasting the nodules in sintering machines. The unit was built at the YuGOK Sintering Plant. Apparently, the dust emission during the roasting of nodules is reduced because one roasts particles 16-25 mm in size instead of finely ground concentrate. To improve the operation of the hydraulic dust prevention system one can use sensing elements, developed by the Mekhanobrchermet Institute, which automatically switch off the sprayer when the conveyor belt is empty.

V. S. Orlov (Krivoi Rog Works) described the shortcomings of the sintering plant of the Krivoi Rog Works. The dust which settles on the platforms and railings in the sintering plant building cannot be washed off because the water gets into the electric substation building. In the design of the sintering plant no provision was made for making the substation watertight. A tank for the granulation of the blast-furnace slag is located close to the sintering plant building and the hydrogen sulfide which is produced during the granulation process penetrates into the sintering plant and other departments.

At the Krivoi Rog Works it was found that moistening the limestone in the hammer mills reduces the dust content in the air in the limestone preparation section.

V. V. Dobroserdov (Magnitogorsk Metallurgical Combine) reported some improvements in the working conditions at the sintering plants of the Magnitogorsk Metallurgical Combine. As a result of the automation of charge distribution to the bins and the automatic charging of materials on the pallets and other operations, as well as the mechanication of maintenance operations, the working conditions improved substantially.

Experiments are being carried out on the removal of sulfur from the gas emitted into the atmosphere by the exhaust fans.

The report by N. O. Romenskii (YuGOK) attracted special attention. At the sintering plants of the YuGOK, a hydraulic method of dust removal from the multicyclone bins was introduced and this made it possible to reduce the dust content in the air in the multicyclone sections to the level specified by safety and health regulations. Dust-removing exhaust fans were installed in the passages where the charge is handled. Efficient wet dust catchers were installed at the exhaust ducts of the discharge sections of the sintering machines, and water-cooled screens were set up at the hearth. The working conditions of the sintering plants were improved and dust-prevention and ventilation services were organized.

N. S. Karpushinskii ("Zaporozhstal'") reported that at the Zaporozhe Sintering Plant an apparatus for the removal of dust, which is produced during the discharge of the sinter to the hoppers, is being built. Hoods through which the dust is sucked off are installed above the hoppers. In this way, the dust content in the air at the plant will be reduced.

During the discussion, D. I. Uryupin (Mekhanobrchermet) stressed that if the sintering process is well organized, the dust emission is substantially reduced. At the YuGOK sintering plants, the concentrate moisture should be reduced to 6-8% and the batching of returns should be improved.

It was stressed in the resolutions of the conference that working conditions at several sintering plants (UuGOK, MMK, "Zaporozhstal'") had been improved. At some plants, however, the improvement in working conditions was progressing very slowly (Makeevka, Enakievka, Kerch).

Design, and scientific and research institutes do not pay sufficient attention to the problems of making working conditions at the sintering plants more healthy.

The Conference recommended the introduction of a hydraulic method of dust removal from the multicylone

bins, the adoption of wet dust catchers, dust-removing fans (as at the YuGOK and "Zaporozhstal'" Sintering Plants) and other practical measures aimed at an improvement in working conditions and safety.

The development and adoption of advanced pneumatic, hydraulic and other methods of handling materials and dust should be speeded up; electrovibrating conveyors should be subjected to additional tests with the object of improving them with regard to working conditions (elimination of noise and of heat radiation from the tubes during the transportation of hot materials).

The Mekhanobr Institute should speed up the design of sintering plant buildings consisting of detached sections (pavilion type).

It is necessary to develop and to introduce speedily the automation of individual sections of the sintering process, making use, in particular, of the experience of the sintering plants of the MMK, "Zaporozhstal'", Vysokogorskoi and other works.

The conference asked the State Planning Commission of the USSR to issue instructions to the works which supply equipment for sintering plants to start the manufacture of dust-extraction hoods and to supply them as an integral part of the basic equipment.

It is necessary to study the experience in the improvement of working conditions and safety techniques at sintering plants more extensively.

The members of the Conference visited the YuGOK and Krivoi Rog Sintering Plants and acquainted themselves with arrangements aimed at improving working conditions and safety.

Cand. Tech. Sci. A. V. Sheleketin

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# THE FIRST CONGRESS OF THE SCIENTIFIC AND TECHNICAL SOCIETY OF FERROUS METALLURGY

D. A. Smolyarenko

Cand. Tech. Sci., Member of the Presidium of the Central Council of the Sci. Tech. Soc. of Ferrous Metallurgy

Translated from Metallurg, No. 1, pp. 43-44, January, 1960

The first All-Union Congress of the Scientific and Technical Society of Ferrous Metallurgy took place in Dnepropetrovsk from September 29 to 30, 1959. About 400 people attended the Congress. The Congress heard the report of the Chairman of the Sci. Tech. Soc. of Ferrous Metallurgy, M. A. Pertsev, on the activities of the Central Council of the Society and on the tasks of the Society in connection with the resolutions of the Central Committee of the Communist Party of the Soviet Union, passed at the Twenty-first Congress and at the Plenary meeting in June, 1959; heard the report of the Inspection Committee; discussed and passed the Statutes of the Sci. Tech. Soc. of Ferrous Metallurgy and elected the Central Governing Body of the Society and the Inspection Committee.

During the period under report (1955-1959) the Sci. Tech. Soc. of Ferrous Metallurgy had carried out a great deal of work aimed at encouraging technologists to introduce extensively the latest advancements in science and technology, and to assist the personnel of metallurgical establishments in fulfilling their socialist obligations. The Society has extensively enlisted the services of technical personnel, scientists, and inventors to solve industrial problems and has actively assisted economic and planning organizations in their work.

In accordance with the resolutions of the Central Committee of the TsK KPSS and VTsSPS, in 1955 the scientific and technical societies were reorganized into popular scientific and technical societies under the management of the trade unions. In this way, the work of the Scientific and Technical Society was improved and direct contact between science and industry was strengthened. In four years the membership of the Society has more than trebled, and at present it has more than 42,000 members and 350 local organizations. During the period under review the Society organized 25 competitions in which 946 members took part.

One should mention in particular the programs of the local organizations at the Petrovskii Works (Chairman of the Council: Malyi) the Dzerzhinskii Works (Chairman of the Council: Sorokin), and the Kuznetsk Combine (Chairman of the Council: Borodulin) which included in their work all the activities of the Sci. Tech. Soc. of Ferrous Metallurgy.

The primary organizations offer scientific and technical assistance to the Teams of Communist Labor – a

new patriotic movement. Many local organizations of the Society established close relations with scientific, research and educational institutes and now work out important industrial problems with these institutes.

The increase in the amount of research work and the appearance of new branches of the ferrous industry urgently require a clear and more rational distribution of work in the scientific field and, first of all, in specialized scientific and research institutes.

The existing forms of organization and the principles of the development of scientific establishments have no doubt made a positive contribution. This has been proved by the present level of science and technology in the ferrous industry of the USSR.

It was stressed at the Congress that now is the time to introduce a system into the network of scientific establishments, and to solve the problem of their distribution and management, taking into account the needs of the national economy.

A systematic exchange of experience among establishments and a creative cooperation between all local councils of the Scientific and Technical Society in the solution of the problems connected with technical advancement now becomes of utmost importance. The exchange of advanced techniques and experience has an exceptional effect on the establishments of the ferrous industry. As an example, one can quote the competitions between the workers of the Kuznetsk and Magnitogorsk Combines and of the Zaporozhe and Cherepovets Works.

The utilization of the metallurgical plants at these establishments is outstanding. Thus, for instance, the open-hearth furnaces at the Cherepovets Metallurgical Works, while working without an intensificator, showed the best results in the USSR. The length of a campaign of the roof is 820 heats. The time of the heat at the single-runner open-hearth furnace is 8 hr 30 min. There is no "ageing" of the furnaces.

Unfortunately, local organizations neither study nor report the work of many other related shops and works in other economic regions. The Institute of Information of the Ferrous Metallurgy of the GNTK USSR, should plan a systematic exchange of information on the perfromance of main shops and plants and on their operating statistics; it is desirable to arrange more frequent visits of specialists for study and technical assistance on the spot.

As an example of the useful effect of such visits we can quote the visit of M. M. Privalov (an active member of the Steel Melter Section of the Society, a foreman, a hero of Socialist Labor, and a Member of the Supreme Soviet of the USSR) to the Cherepovets Metallurgical Works where he helped to sinter the bottom of a new large-capacity open-hearth furnace which was put into operation at the end of September 1959, and helped in developing a rational method of preparing the charge.

Not so long ago, it was considered that all forms and types of charge materials can produce steel of the same high quality and ensure (depending on the refractory materials) an adequate service life of the furnace roofs. M. M. Privalov showed for the first time that with the improved technique of steel melting, appropriate slag control and the use of not more than 60% liquid pig-iron in large-capacity open-hearth furnaces one can obtain a high-quality steel and ensure the maximum service life of the furnaces, provided that the man in charge of the heat has the necessary knowledge of the physical and chemical characteristics of the charge and knows the correct methods of handling the charge and also has adequate experience. The term "the quality of the steel" has a real meaning only in conjuction with the particular destination of the steel.

The recent year's work of the Central Council of the Sci. Tech. Soc. of Ferrous Metallurgy showed that a very effective and fully justified form for the exchange of industrial experience between establishments is the interworks courses for advanced techniques. Steel melters recollect how useful they found the course for studying the work methods of M. M. Privalov, who, together with his staff, achieved the lowest idling time of open-hearth furnaces during repairs to the bottom. Now many steel melters are using his method for sintering the furnace bottom. As a result, idling periods during repairs to the furnace bottom have been reduced by 1-2% so that in large-capacity open-hearth furnaces alone an additional 100,000 tons of steel per year could be produced.

The interworks courses on steel pouring were very useful. As is known, in 1955 the operating statistics on top-pouring and bottom-pouring of steel were studied and it was shown by the example of Magnitogorsk, Kuznetsk and Nizhne Tagil Metallurgical Combines that the first method has several advantages over the second. Unfortunately, not all the recommendations of this course have been realized.

Significant results have also been achieved by the interworks course for the study of the operation of open-hearth furnaces with the use of compressed air for speeding up the steel-melting process. It is planned to study and discuss this problem in more detail in 1960. As a result of the work of this course, it is proposed that a comparative evaluation of all existing methods of the intensification of the open-hearth process should be prepared.

At several metallurgical works the councils of local organizations of the Society assume the functions of a technical advisory council. Local organizations of the Society discuss and submit to the directors of establishments suggestions on the development of new designs of metallurgical furnaces, on technological improve-

ments, on the introduction of new steel grades, on the modernization of obsolescent equipment, on improving the quality of the product and on the adoption of the latest control methods, on finding ways of increasing operating efficiency, etc.

The Scientific and Technical Society at the Makeevka Metallurgical Works led by V. O. Kulikov and B. R. Ratner, has done a great deal in this respect. A new economic type of reinforcing steel, grade 35GS, has been developed and an experimental consignment of this steel to replace steel 25G2S, used for reinforced concrete constructions, has been supplied. This creative work made it possible to speed up the Government's program with regard to saving manganese in steel production.

Recommendations on saving nickel in steel production are being worked out on the initiative of the Steel Melting Section of the Central Council jointly with the local organizations of the Scientific and Technical Society of Ferrous Metallurgy at the Kuznetsk Combine. Recommendations on the replacement of some high-alloy steels by steels of a simple composition and with a smaller amount of additions have been worked out. This substitution is justified by the fact that with regard to the physical and mechanical properties, steels with a small nickel content are not inferior and sometimes are even superior to steels of a high nickel content, and there is no need to change the equipment for processing this steel.

Concrete proposals regarding an additional production of double-layer plate steel in several regions with the object of meeting the needs of the expanding machine-building industry have been put to the State Planning Commission of the USSR.

During the period under review, 18 All-Union Conferences were held: on blast-furnace and sintering processes, on steel melting, steel rolling, pipe production, oxygen application, automation, etc. The best specialists in the country attended these conferences, which provided opportunity for them to discuss and disseminate a tremendous amount of experience and thus to formulate resolutions and recommendations embodying the latest advancements of science and technology, and to prepare proposals regarding the adoption of new techniques and the development of advanced methods. Unfortunately, however, because of the lack of systematic supervision of the realization of the proposals and recommendations, several of them were not put into practice in our industry.

For instance, the resolutions of the Conference on the Use of Oxygen held in July, 1958, on the initiative of the Ukrainian Institute of Metals have not yet been put into practice.

The Sci. Tech. Soc. of Ferrous Metallurgy should encourage competition between scientific and research institutes and design and construction organizations and direct this competition toward an early and successful solution of scientific and technical problems and the adoption of scientific and technical advancements in the industry.

The Congress elected the Central Council of the Society which comprised 55 members and included the First Deputy Chairman of the State Scientific and Technical Committee of the USSR, a Hero of Socialist Labor, P. I. Korobov; a Corresponding Member of the Acad. of Sci. USSR, A. M. Samarin; Academician A. P. Chekmarev; Doctor of Tech. Sci. I. N. Golikov; Chairman of the Central Committee of the Union of Metallurgical Workers, V. A. Podzerko; and others. The Congress elected M. A. Pertsev, a specialist in the field of high-quality metal production and Director of the "Serp i Molot" Works, Chairman of the Central Council of the Society.

# METALLURGIZDAT BOOKS AVAILABLE AT THE KNIGOTORG BOOKSHOPS

Translated from Metallurg, No. 1, p. inside back cover, January, 1960

S. G. Bursanovskii. The First Undertaking of Siberia's Metallurgical Industry (an essay on the Kuznetsk Metallurgical Combine). For popular reading. 1958. 3 r. 55 k.

V. A. Goncharenko and N. B. Rozenfeld. Advanced Experience on Pipe Rolling with Automatic Machines. For workers and foremen in the pipe industry. 1959. 2 r. 25 k.

V. N. Grigor'ev. Circular Reheating Furnaces. For the technical personnel of metallurgical and machine-building works and for students. 1958. 10. r. 25 k.

N. P. Dyubin and V. V. Trofimov. The Quality of Rails. For technical personnel of metallurgical works and for specialists on the design and operation of railroads. Perhaps useful for university and technical-school students. 1959. 7 r. 65 k.

P. T. Emel'yanenko, A. A. Shevchenko, and S. I. Borosov. Rolled and Welded Tubular Products. Textbook for schools and foremen courses. 1954. 11 r. 60 k.

A. A. Zilberman and E. A. Kulinok. Handbook on the Repair of Blast Furnaces and Open-Hearth Furnaces. For technical personnel and foremen. 1957. 17 r. 20 k.

D. G. Ignatenko and A. L. Stareselskii. The Operator at the Control Posts of a Rolling Mill. Textbook for the technical education of workers. 1957. 4 r. 60 k.

The Zakavkaz Metallurgical Works. By a group of authors. For popular reading. 1959. 6 r. 5 k.

V. F. Kopytov. Steel Heating in Furnaces. For technical personnel of metallurgical and machine-building works. 1955. 10 r. 15 k.

N. K. Leonidov. The Erection and Equipping of Blast-Furnace Shops. Textbook for University Metallurgy Departments and for designers, constructors and operators of blast-furnace shops. 1955. 12 r. 85 k.

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V. Ya. Ostrenko and P. I. Vatutin. Pipe Production on Automatic Mills. For technical personnel and university students. 1958. 4 r.

M. Ya. Ostroukhov. Boosting the Blast-Furnace Process. For engineers, technicians, foremen and research workers. 1956. 8 r. 70 k.

M. A. Pavlov. Burdening the Blast Furnace. For engineers, technicians and foremen. 1951. 9 r. 5 k.

A. G. Romanenko. Pig-Iron Casting and Blast-Furnace Slag Disposal. For technical personnel, and university and technical school students. 1957. 8 r. 80 k.

Collection of articles (translation from English by P. I. Grudnev). Energy Consumption in Steel Rolling and the Selection of Electric Motors. For electrical engineers engaged in rolled steel production; for steel rolling engineers and university students. 1958. 3 r. 50 k.

E. I. Tishchenko and A. S. Emel'yanov. Dismantling and Bricklaying of Blast Furnaces. A textbook for the technical education of workers. 1957. 9 r.

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Yu. M. Fainberg and A. B. Zelenov. The Control of the Electric Motor of Continuous Hot-Rolling Mills. For designers, maintenance and operating personnel and

laboratory workers at metallurgical works. 1956. 8 r. 70 k.

Ya. A. Shneerov. The Large-Capacity Open-Hearth Furnace. For technical personnel of metallurgical establishments. 1956. 3 r. 40 k.

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## SIGNIFICANCE OF ABBREVIATIONS MOST FREQUENTLY ENCOUNTERED IN SOVIET PERIODICALS

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|---|---|
| FIAN | Phys. Inst. Acad. Sci. USSR. |
| GDI | Water Power Inst. |
| GITI | State Sci.-Tech. Press |
| GITTL | State Tech. and Theor. Lit. Press |
| GONTI | State United Sci.-Tech. Press |
| Gosénergoizdat | State Power Engr. Press |
| Goskhimizdat | State Chem. Press |
| GOST | All-Union State Standard |
| GTTI | State Tech. and Theor. Lit. Press |
| IL | Foreign Lit. Press |
| ISN (Izd. Sov. Nauk) | Soviet Science Press |
| Izd. AN SSSR | Acad. Sci. USSR Press |
| Izd. MGU | Moscow State Univ. Press |
| LÉIIZhT | Leningrad Power Inst. of Railroad Engineering |
| LÉT | Leningrad Elec. Engr. School |
| LÉTI | Leningrad Electrotechnical Inst. |
| LÉTIIZhT | Leningrad Electrical Engineering Research Inst. of Railroad Engr. |
| Mashgiz | State Sci.-Tech. Press for Machine Construction Lit. |
| MÉP | Ministry of Electrotechnical Industry |
| MÉS | Ministry of Electrical Power Plants |
| MÉSÉP | Ministry of Electrical Power Plants and the Electrical Industry |
| MGU | Moscow State Univ. |
| MKhTi | Moscow Inst. Chem. Tech. |
| MOPI | Moscow Regional Pedagogical Inst. |
| MSP | Ministry of Industrial Construction |
| NIIZVUKSZAPIOI | Scientific Research Inst. of Sound Recording |
| NIKFI | Sci. Inst. of Modern Motion Picture Photography |
| ONTI | United Sci.-Tech. Press |
| OTI | Division of Technical Information |
| OTN | Div. Tech. Sci. |
| Stroiizdat | Construction Press |
| TOÉ | Association of Power Engineers |
| TsKTI | Central Research Inst. for Boilers and Turbines |
| TsNIÉL | Central Scientific Research Elec. Engr. Lab. |
| TsNIÉL-MÉS | Central Scientific Research Elec. Engr. Lab.-Ministry of Electric Power Plants |
| TsVTI | Central Office of Economic Information |
| UF | Ural Branch |
| VIÉSKh | All-Union Inst. of Rural Elec. Power Stations |
| VNIIM | All-Union Scientific Research Inst. of Meteorology |
| VNIIZhDT | All-Union Scientific Research Inst. of Railroad Engineering |
| VTI | All-Union Thermotech. Inst. |
| VZÉI | All-Union Power Correspondence Inst. |

Note: Abbreviations not on this list and not explained in the translation have been transliterated, no further information about their significance being available to us - Publisher.